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SURGICAL CONVALESCENCE

BY

F. Curtis Dohan and N. Henry Moss (*Conference Co-Chairmen*), M. W. Allam, K. G. Bartels, F. B. Berry, E. Day, J. E. Dunphy, A. J. Fleming, D. Gold, J. D. Hardy, P. R. Hawley, C. G. Johnston, A. Keys, J. E. Martin, F. D. Moore, J. H. Powers, I. S. Ravdin, H. A. Rusk, H. J. Saffeir, A. M. Sutherland, and H. L. Taylor

Consulting Editor
F. Curtis Dohan

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INTRODUCTORY REMARKS

By Emerson Day

Memorial Center for Cancer and Allied Diseases, New York, N.Y.

Surgical convalescence is a subject of vital interest to everyone concerned with medical care. However, the breadth of the field, as revealed by the titles of the papers that follow, necessitates special efforts if the results of our varied investigations are to be integrated and made available both for further research and for practice. This monograph is the fruit of such an effort, and its scope should make it especially useful for everyone involved with medical care.

Great progress has been made in the understanding and management of surgical convalescence during the past two decades. Efforts in this field have not only given impetus to new phases of medical care but have accelerated research and knowledge in basic physiology. Policies governing ambulation and the length of hospital stay have been drastically revised. A new look is being taken at the schedule of return to activity and to full work following various types of surgical procedures. All this has medical and socioeconomic implications of major importance, and these receive careful consideration in the following pages.

Because of these developments, which have made possible a marked reduction of the time required for hospitalization, one would expect the period of convalescence, that is, until the return of the patient to full activity, to have been similarly reduced. This has not occurred, and the fact that total convalescence may be prolonged unduly calls for explanation. The following papers provide considerable enlightenment on this question.

INTRODUCTION

By I. S. Ravdin

School of Medicine, University of Pennsylvania, Philadelphia, Pa.

We have come to speak rather freely regarding a variety of the factors either partially or totally involved in the specific problems of surgical convalescence. Nevertheless, we do not fully understand many of them, as a closer look demonstrates. One purpose of this monograph is to define the relevant areas more clearly in order to discover the limitations of our present understanding.

The authors represented here are well equipped, not only for this purpose, but also to extend our knowledge in the various areas of their own research. Their wide variety of interests, all of which relate to convalescence, means that their papers cover the entire period of convalescence from the minutiae of tissue behavior through the psychological elements involved.

The problem of the healing of wounds has always been an important one, and we know from Hippocrates' writings that even in his time it was being treated as a signifigant aspect of surgery. Despite this, little advance was made until the Sixteenth Century, when the son of a French joiner and gardener, Ambroise Paré, the greatest of the barber surgeons, gave renewed vigor to surgery by rejecting the old Arabic treatment of wounds by cautery and instillation of hot oil. It was Paré who first emphasized the gentle cleansing of wounds. In writing about the treatment of wounds on the faces of women he advocated the use of a "dry suture, for they are so covetous of their beauty." Poorly educated in his early life, he became the surgeon to three kings of France. By the time he read the works of Hippocrates, Galen, and the other great medical writers, he had excelled them all in the conditions he had been called upon to treat.

The healing of wounds of the skin and of subcutaneous tissues is no longer the sole aspect of the surgeon's concern, for the problem is now known to be far more complex. Moreover, even the repair of tissue has proved far more complex than it was once thought to be; fortunately, the factors involved are also far more clearly understood. Harry A. Davis has recently outlined the questions still unsolved as follows:

"Many questions arise which have to be answered, some of them paradoxical: How can trauma, which produced the wound, be itself the stimulus to repair; do tissues differ in their reparative capacities; at what rate does wound healing occur; is it possible to accelerate the repair of tissues; what initiates the healing process; what stops the healing process and prevents it from proceeding to the point of tumor formation; what are the chemical processes involved in healing; and what factors impair the rate of healing?"[1]

There are numerous biological processes that govern the repair of tissues, whatever their origin, as well as considerable biological variation in the rapidity with which the same tissues can repair themselves. The liver, for instance, has an irresistible propensity to regenerate, even under conditions that are far from favorable. Certain nerve tissues do not regenerate at all, and others do so at an exceedingly slow rate. Clearly, the ability of tissues to regenerate plays an important part in the restoration of the patient to health. The phenomena that occur after tissue injury and the magnitude of the physiological response to injury are discussed in the following papers.

Another important question concerns the building stones of repair and how they are used. Some years ago a group of us at the Harrison Department of Surgical Research became interested in superficial wound repair. We wondered whether any agent applied topically really accelerated the healing of a wound. Although the literature abounds in papers purporting to demonstrate that one agent or another actually does stimulate healing, most of these studies lack critical and objective evidence. In most instances we found that the agent applied had nothing to do with the healing of the wound; however, our study again demonstrated the well-known fact that, as long as necrotic tissue is present, a wound will not heal but, once the necrotic tissue is removed, healing proceeds normally or abnormally, depending on a number of biological processes. The extent to which healing is impaired by a variety of physiological circumstances is given clearer definition in this monograph.

One paper is concerned largely with certain other factors that must be taken into account as criteria of convalescence, such as nutrition in relation to the deterioration of strength and endurance, alterations in behavior patterns, and the loss of fitness in the broadest sense.

Long before early ambulation was being recommended in this country, many German surgeons were pointing out that exercises done in bed facilitate convalescence. Such exercise was being recommended—even prior to our realization that a negative calcium balance and osteoporosis follows periods of immobilization of an extremity—as capable of reducing certain complications of anesthesia and operation and of assisting in the preservation of muscle and joint function.

The failure to understand adequately the biological importance of in-bed exercises and out-of-bed ambulation has led to their misuse. Causing a patient undue pain or unduly tiring a patient are obvious misuses. There are other considerations, also, especially with regard to early ambulation, and these are dealt with in the following pages.

John Hilton clearly described the physical reactions of adaptation to injury in his 1860–1862 lectures given before England's Royal College of Surgeons. Concerning the body's physical response to injury, he said: "Entertaining as I do the most exalted admiration of Nature's powers of repair, the thought has not infrequently occurred to my mind, when watching cases of extensive injury, what would have been the condition of man on earth had it pleased the Creator to withhold from him this power of repairing his injured tissues."[2] John Hilton believed sincerely in rest for injured tissues, for he went on to say: "Under injury, pain suggested the necessity of, and indeed compelled him (the patient) to seek for rest."

To what extent is rest necessary and beneficial, and to what extent does prolonged rest delay complete convalescence? There can be no doubt that rest is of enormous value. On the other hand, it has been established that early ambulation, if cautiously employed, can play a part in the return to a positive nitrogen balance, an improvement in respiratory function, an increase in appetite, improved confidence on the part of the patient, and a variety of other important functional activities that far outweigh many of the dangers inherent in a patient's early ambulation after surgery.

It has been said that early ambulation does not really reduce the incidence of postoperative complications. With respect to thrombosis and embolism, this may be true, but that early ambulation, if properly planned and adequately executed, can lessen the period of surgical convalescence is clearly demonstrated by one of our authors.

Other elements, which are not strictly biological, play an important part in the return of a patient to his work. These are the problems associated with motivation, and they can prolong convalescence even when every conceivable physiological circumstance seems to have returned to normal. Insight into the motivation of patients is provided and the question why certain patients do not recover readily is explored in one of the papers.

Another paper raises the question of why there is so little general agreement in our profession as to the proper advice concerning convalescence for patients who have undergone the same operation. In so doing, the author makes it clear that performing an operation is not the whole of surgical therapeutics. The preparation of the patient adequately to withstand anesthesia and operation and the maintenance of homeostasis in the postoperative period must be of primary concern to the surgeon.

Finally, the surgeon must be interested in both the physical and the emotional rehabilitation of his patients. Complete physiological rehabilitation encompasses psychological as well as biological recovery. One of our authors makes it clear that the desire to work is, at times, more important for convalescence than the ability to work. The emotional outlook of the patient must not be forgotten under any circumstances, and this is especially true in convalescence from prolonged illness.

Convalescence must be viewed as a single aspect of the entire process of rehabilitation, for convalescence is not complete until, as the result of training and motivation, the patient returns to some type of work. The entire problem, therefore, is a very broad one. It demands a many-faceted outlook for its complete solution, and much light is shed on these facets in the following pages.

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GETTING WELL: THE BIOLOGY OF SURGICAL CONVALESCENCE*

By Francis D. Moore
Peter Bent Brigham Hospital, Boston, Mass., and Harvard Medical School, Cambridge, Mass.

Introduction

At first glance, the titles in this monograph may seem too widely divergent; some papers discuss the necessities of keeping the sick alive, while others examine the problem of returning the alive to work. Nevertheless, I believe all would agree, not only on the unity of the effort, but also that its extent demonstrates the true magnitude of the field of human learning called surgery. The doctors working in either of these areas—the surgeon dealing with the man in shock or the physical therapist rehabilitating him six months later—are both dealing with the same biological phenomenon, namely, the process of getting well after injury.

I shall first review briefly some aspects of the biology of getting well, that is, of convalescence in the usual sense. Convalescence includes all the interlocking physical, chemical, metabolic, and psychological factors commencing with the injury, or even slightly before the injury, and terminating only when the individual has returned to normal physical well-being, social and economic usefulness, and psychological habitus. The patient will always carry the scar of his injury, and in that sense he will never be the same again. However, since convalescence must be said to terminate somewhere, we have chosen the criteria of the social and economic rehabilitation of an individual, that is, that he is psychologically and physiologically restored to full effectiveness.

In 1950, when reviewing metabolic balance studies undertaken in surgical patients, we began to discern a series of dynamic phases of convalescence. Our studies were crude in the extreme, being merely the measure of the intake and output of nitrogen, sodium, and potassium and a correlation of these with the patient's clinical behavior, certain aspects of his body composition, and the familiar laboratory studies of blood counts and chemical analyses. In 1952 we published a brief account of some of these changes[1] and, a year later, I solemnized the four phases of convalescence in a further publication.[2] In the latter I referred to our concept of the four phases of convalescence as a theory of convalescence, a theory that might provide a stimulus to further study—a framework on which to hang observations as they became available—one which, like all theories, would be subject to modification as new data became available.

These four periods of convalescence are dynamic biological phases in the

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injured man and can be conceived of as possessing a finite objective. The process is analogous to that of pregnancy.

In pregnancy there are changes in the appearance and feeling of the patient. The woman looks different, feels different, has different psychological problems, and in many ways is a different person. There are local changes in tissues—in the uterus, the fetus, the ligaments of the pelvis, and the breast—as well as changes in metabolism. The amount of body water and its rate of turnover tend to increase. Salt is retained and there are alterations in renal function. There are endocrine alterations: increases in the secretion of estrogen and, later, of progesterone, and a new endocrine site in the form of the placenta. The whole process terminates in labor and parturition, the birth of a baby and, within a few days, a relatively uneventful restoration to work on the part of the mother.

By analogy, surgical convalescence involves changes in the appearance, feeling, and appetite of the patient, which I need not describe in detail. Anyone who has had a major operation is familiar with them. There are changes in local tissue, namely, changes in the wound, which are the morphologic and chemical changes of healing. There are alterations in the metabolism of nitrogen, water, and salt, and alterations in body composition. There are endocrine changes, including those in the adrenal glands, the pituitary and, possibly, the gonads and the thyroid, and the surgical patient, too, may have a new endocrine site, the wound. Finally, the entire process of convalescence terminates in a patient rehabilitated to health, strength, and work.

It can be seen from this analogy that our theory of convalescence as involving four phases is merely a way of expressing the dynamic changes that occur from day to day and week to week, in getting well.

These four phases are not always exactly the same. In long-bone fractures, for instance, the loss of nitrogen far outlasts the period of caloric starvation, whereas in elective soft tissue surgery of moderate extent the two are almost contemporaneous. In burns the formation and diuresis of the large volume of traumatic edema dominate the early phase. In minor tissue trauma almost all the changes seen in body composition may be reversed by high-calory diets. Nevertheless, although the phases and changes are not always the same in every patient, there are certain underlying common denominators that permit us to dignify these dynamic periods as actual phases of convalescence.

This paper reviews these four phases briefly, emphasizing that duration and correlation are not rigid. It then examines some of the recent data relevant to the unfolding of this process of convalescence in the surgical patient: the nature of trauma, the mediators from the wound to the tissues, the meaning of the endocrine response, the relation to starvation, and the meaning of nitrogen metabolism to the wound.

The Four Phases of Convalescence

(*1*) *Injury.* In this period, which starts with the trauma, body composition is characterized by a loss of lean tissue and fat and a relative gain in body water and the extracellular phase. Much of this new extracellular phase may be sequestered in traumatic edema, in which case the functional extracellular phase may actually be reduced. The corticosteroid changes are most marked within the first few hours of illness, and there is clear evidence of a tendency to withdraw water and salt from the renal tubule. The loss of lean tissue is manifested by a loss of nitrogen from the body, the extent of which is roughly proportional to the severity of the injury. The patient is weak and listless, has no ambition or appetite, and wants to be quiet and alone. This phase of convalescence runs its typical course in the absence of any exogenous intake of food, and the patient rarely has any appetite or desire for food. He lies quietly in bed and usually does not take much of an interest in his surroundings. The wound accumulates an amorphous coagulum of water and solutes with leukocytes and monocytes. There is no tensile strength. After moderately severe elective soft tissue surgery without sepsis, this phase lasts two or three days.[3]

(*2*) *The turning point.* This period of convalescence has been recognized by surgeons for many centuries. At present, interns and residents state that women at this period of convalescence show a "positive lipstick sign," meaning that the patient now takes renewed interest in her surroundings. She turns a corner toward recovery.

There is a distinct tendency toward a decrease in the rate of lean tissue catabolism. The most characteristic metabolic aspect of this phase of convalescence is a reduction in the absolute urinary nitrogen excretion rate, even during increasing intake. There is an increase in gastrointestinal function, with a return of peristalsis, the passage of flatus by the rectum, a desire for food, and a diuresis of water and salt. This phase may last only a day or two.

The wound now very rapidly gains tensile strength, collagen appears, and fibroblasts are more abundant. Sutures may be removed at the end of this time.

(*3*) *Spontaneous nitrogen anabolism: strength.* This is the long period of spontaneous anabolism and muscular regrowth. It will not occur without diet. The characteristic sequences of convalescence will proceed quite normally up to this point without any exogenous intake of calories or food. One may argue that such intake reduces the wastage of tissue early after trauma and, in minor injury, this is indeed easily demonstrated. The fact is, however, that the injured man passes through the first two phases of convalescence quite normally without diet. Now, as he approaches the third phase, the situation is changed remarkably. Normally, dietary intake begins in a stepwise fashion, whereby the patient gradually approaches his preoperative normal of about 2400 calories, with a calorie-nitrogen ratio of 200. This intake permits anabolism. In the normal adult human, the normal nitrogen balance is zero. It is therefore remarkable to note that after injury a prolonged nitrogen anabolism ensues that is characterized by the synthesis of protein and the laying down of new tissue, primarily in skeletal muscle. Skeletal muscle, having shrunk in size while serving as the nitrogen donor during the early phase, now receives the benefits of spontaneous anabolism. During this period the patient gains strength and, after civilian surgery, can be sent home. The rehabilitationist institutes suitable exercises or other steps undertaken for those injuries in which muscular re-education is necessary. It should be emphasized that exogenous caloric intake must be in excess of work output if protein synthesis in muscle is to occur. Therefore, the patient should not return to work too soon.

This phase of convalescence comes to an end when the lean tissues of the body have been restored to that absolute magnitude determined by the genetic constitution, the sex, the age, and the external work requirement of the individual.

The wound is now strong, but still very active. The thin red line becomes a heaped-up cicatrix that may border on the keloid.

(4) *Fat redepostion: the fat-gain phase.* The patient continues to gain weight for several more months. For instance, after a major abdominal operation such as a combined abdominal-perineal resection, the patient's weight may increase for three to five months. During the final weeks or months of this period, nitrogen balance is not positive, but the patient is continuing to gain weight while total body water remains constant, the trademark of fat gain. This late phase therefore represents the regaining and redepostion of the fat that was oxidized in the early period of low intake and energy demand from the resources within the body. The wound flattens and becomes white, ceasing to appear as a thick and prominant cicatrix.

When the patient's body weight has returned to normal, the fat-gain phase is over and biological convalescence has ceased, although abnormalities and activity in the wound may be discernible for many many months or years.

Magnitude of the Trauma

It should be emphasized that the four phases of convalescence are not rigid in character; individuals vary. The preoperative status of the patient, particularly with respect to nutrition, makes a difference in the metabolic changes that follow. Then too, men have a stronger and more profound response than do women. A previous operation, if sustained within a month or so, will drastically alter the patient's response. Nevertheless, the same general sequence is discernible: an injury phase with nitrogen loss followed by a brief turning point with diuresis, then nitrogen anabolism and, finally, redeposition of fat. Of principal interest in this sequence, however, is its relation to the magnitude of the antecedent trauma.

In 1950 I proposed a simple "scale of ten" to indicate the approximate magnitude of injury. This scale was conceived in terms of the sum total of the components of injury, the cross-sectional tissue trauma, the duration of trauma, and the magnitude of the actual operation. At one end of the scale, scale 1, is very minor injury such as a simple herniorrhaphy in a child, or a sprained ankle. At midscale lie the major abdominal operations commonly undertaken. At scale 7, 8, or 9 are the major multivisceral operations and operations accompanied by shock or followed by infection and, at scale 10, is the very serious injury involved in a major burn or a war wound with traumatic amputations, multiple penetrations, infection, and shock.

Whether one looks at the patient immediately after the operation, talks with the anesthetist, inspects the chart, counts the number of empty bottles in the blood bank, talks to the nurse, or checks the metabolic data, a range in injury is apparent from minor, through moderate, to severe. This simple scale of ten was merely a way of expressing this relationship and was thus described: "This scale, like that used by mariners to express the force of a blow, may depend on the experience of the skipper, which way he is looking and how hard it blew yesterday. But still a hurricane looks different from a good stiff racing breeze, a zephyr from a flat calm."

John Howard, now at the Hahnemann Medical School, Philadelphia, Pa., who, with his group working in Korea during the war, so enhanced our knowledge of trauma through studies of unanesthetized injury in the combat soldier, also added greatly to the usefulness of this concept of a scale of injury by changing it from one of ten to one of forty. In this scale many different factors were graded, such as duration from injury to resuscitation, duration of shock, number of transfusions, factors of fever, location of injury, and viscera involved. This facilitates a far more accurate comprehension of the complexity and biological significance of the injury.

More recently I have been interested in expressing this scale of injury in direct terms of the biological components of trauma involved, which produce many of the changes seen. In 1951 we began to study the biological components of surgical trauma separately. Anesthesia, starvation, immobilization, antidiuresis, adrenocortical response, and controlled hemorrhage now have all been studied as separate stimuli. The true magnitude of surgical trauma represents the accretion of these biological components. They seem to fall into the following three general groups, which are additive.

(*1*) *Minor stimuli.* These stimuli, comprising immobilization, starvation, anesthesia, fear, cold, pain, fatigue, and minor tissue injury, will alter body composition and, in many instances, adrenocortical and renal function, in a way similar to that seen in minor surgery. However, they are transient; the changes are small and quickly reversed. Many of the compositional changes such as negative nitrogen balance can be completely avoided by feeding. This is most typical of starvation. When these are mixed with minor tissue trauma, we have the group 1 stimuli, or minor injury.

(*2*) *Threatening challenges.* These factors, consisting of plasma volume loss, blood volume loss, desalting, dehydration, traumatic edema, hypotension, anoxia, hypercarbia, and major tissue injury, threaten the organism in surgical trauma and summon far stronger homeostatic forces than do those in the first group. These are encountered in any severe or extensive surgical operation. Probably the most significant with respect to water and salt metabolism is the reduction in the effective volume of circulating blood. Evidence is increasingly convincing that the chief stimulus to adrenocortical output of 17-hydroxycorticosteroids and of aldosterone is reduction in effective circulating blood volume, whether this occurs as a result of hemorrhage, traumatic edema, dehydration, desalting, or other factors. Anoxia and hypercarbia are also strong stimuli to homeostatic forces, involving peripheral vasoconstriction, catechol amine output, and an increase in both loss of nitrogen and tendency to retain salt and water.

(*3*) *Tissue-necrosing trauma.* When sepsis, gangrene, necrosis, shock, and very extensive tissue injury are added, necrotic or anoxic tissue is found in the body for prolonged periods of time. In sepsis, the tendency to excrete nitrogen is far greater than that accounted for by the rim of tissue directly involved. One must ask what the mediator is in such a case (see below), but the empirical fact remains that infection is a strong stimulus to all the endocrine and compositional changes seen after trauma without infection.

The presence of necrotic tissue in the body as, for instance, in gangrene or crush, greatly increases the hazard to the organism, and is associated with a particular threat to the kidney. Prolonged shock involves a deficiency of flow that brings in its train a whole series of interlocking biochemical alterations. These might be called the intermediary metabolism of tissue anoxia: the accumulation in the blood of products of incomplete or abnormal intermediary metabolism of fat, protein, and carbohydrate and the accumulation of intracellular materials in the extracellular phase. When this third group of stimuli is present, we are nearly always dealing with injury sufficiently severe to be grouped in scale 8, 9, or 10 in the simple scale of ten.

An increase in the extent of cross-sectional tissue injury itself involves an increasing biological response. It is difficult, however, to separate this from the biological components mentioned above. There is a difference, however. A comparison, for instance, of simple mastectomy to radical mastectomy shows the difference in so-called extent of tissue trauma. It is possible that the mere factor of extracellular fluid accumulation in the wound, or blood loss, could account for most of the differences in water and salt metabolism between the two operations. This aspect continues to be an interesting facet of the magnitude of trauma, and further study is needed to define the meaning of cross-sectional tissue injury in relation to the extent of trauma.

Mediators of Injury

In viewing the bodily effects of injury, it is essential to postulate the existence of mediators. An example will illustrate this. After a midshaft fracture of the femur, the patient calls on the fat and lean tissues of his body to an extent far greater than he does in simple starvation or in combinations of starvation and immobilization. The size of his opposite quadriceps, trapezius, and deltoid muscles and his subcutaneous fat all decrease. In addition, he shows early changes in the renal excretion of water and salt and, later, alterations in energy requirement. Moreover, all these occur without sepsis, but they are greatly increased, not only by sepsis but by any of the other major stimuli listed in group 3.

It is essential, therefore, to realize that while mechanical force directly applied has broken the femur, something else has brought the message of injury to the other tissues of the body to initiate the widespread changes that ensue. I call these messengers "mediators of surgical injury." They appear to fall into two general classes, the nonendocrine and the endocrine mediators.

Nonendocrine mediators. Recent interest in the endocrinology of the surgical patient has tended to overshadow the importance of the nonendocrine mediators of tissue injury, namely, the alterations arising from the wound itself that produce diffuse bodily changes. These bodily changes occur as a result of the wound and require no intermediation of the endocrine glands. The nonendocrine mediators of tissue injury are virtually all harmful; they constitute the basis of wound surgery in the sense that effective definitive operation after injury terminates their action and permits convalescnce. There are six nonendocrine mediators:

(1) Injury to the central nervous system with altered consciousness, decreased ventilation, coma, restlessness, and inability to vasoconstrict.

(2) Injury to the airway with anoxia and hypercarbia. This injury may occur at any level.

(3) Decreased effective blood volume with prolonged deficiency of flow and shock.

(4) Cross-sectional tissue injury with necrosis, cutting, tearing laceration, discontinuity of structure with cation exchange in the local tissue, and release of intracellular substances into the circulation.

(5) Contamination leading to infection. Breaks in the skin or in the internal mucosal barriers as seen in external wounds and in the rupture of esophagus, stomach, bowel, gall bladder, ureters, urinary bladder, and the other viscera. Breaks in the ectoderm or entoderm permit the entry of organisms leading to sepsis.

(6) Starvation. Severe injury is inevitably followed by a decreased period of oral intake of food. Starvation does not represent an immediate threat to the survival of the individual but, if prolonged, it contributes to the lysis of lean tissue, glycogenolysis, gluconeogenesis, the oxidation of fat, and the gradual decrease in the size of the intracellular compartment, with a tendency toward a gain in relative body water and extracellular phase.

These nonendocrine stimuli are responsible for widespread bodily changes and for the deterioration of the patient after injury. If they proceed unchecked, they end in death. The care of the wounded man, starting with first aid and proceeding to the termination of his definitive surgical operation, is based entirely on control of these six nonendocrine stimuli. Their implications in surgical care have been described in a recent Lister Lecture.[4]

Endocrine mediators. In addition to the nonendocrine mediators responsible for diffuse bodily changes after trauma, there are four endocrine mediators that seem to be activated after trauma. Their influence on tissue change and convalescence has been the object of much study in the past fifteen years and has stimulated considerable current controversy. There are four endocrine mediators:

(1) The corticosteroids of the adrenal cortex as epitomized by compound F. This material is secreted in large quantities immediately after trauma, as demonstrated by studies on adrenal-vein blood. It is altered in its intermediary pathway, reduction, conjugation, and excretion by injury itself. As mentioned above, it seems to have its chief significance in the maintenance of vascular homeostasis since, in its absence, the most marked change is that of uncontrollable hypotension and shock.

(2) Aldosterone. It can be demonstrated that this salt-active material is increased after injury. The most potent stimulus to the increase in secretion of aldosterone appears to be reduction in effective volume. The term effective volume is intentionally vague: whether it refers to the "sodium space volume,"

that is, the true support of the plasma volume in the interstitial phase, or whether it represents blood volume alone, or both, is not clear. An increase in aldosterone secretion is seen almost immediately following reduction in blood volume. Changes in renal function can readily be shown as due to aldosterone. I postulate that aldosterone also plays an important role in the exchange of potassium for hydrogen and sodium in muscle cells, and thus in the mobilization of cell water. Some workers have indicated a linear relationship between the urinary sodium-potassium ratio and the urinary aldosterone excretion in surgical patients. Others have failed to find this. The causal relationship here is unknown at this time.

(3) The catechol amines of the adrenal medulla. Recent quantitative methods have demonstrated marked and regular increases in catechol amine excretion in the urine following surgical trauma. Studies of the blood by current methods are far less revealing. One does see rises in the catechol amines in the blood after certain types of trauma. In the dog, a rise in the catechol amine levels in the adrenal-vein blood is produced immediately by certain forms of anesthesia and by simple venous hemorrhage, as well as by complex tissue trauma. Decreased effective volume with prolonged deficiency of flow and shock appears to be the most potent stimulus to the output of these materials.

(4) Antidiuretic substances. Whether or not the posterior pituitary is stimulated directly by trauma in order to produce an increased secretion of antidiuretic hormone is uncertain, and will doubtless remain so for some time. The evidence, however, is very suggestive. After a hypophysectomy, one does not see the transient period of antidiuresis observed after other forms of trauma. Antidiuretic substances have been isolated in the blood and urine of surgical patients. The postoperative metabolism of a water load exactly resembles that seen after the administration of vasopressin. It is highly probable that alterations in intermediary metabolism of the antidiuretic hormone, as well as other changes in renal function, particularly hemodynamic factors, are important here. Volume reduction is a very potent stimulus in this case, as are also ether anesthesia, water deprivation, and desalting water loss.

Factors in the Endocrine Response

It has been known for ten years that the later phases of surgical convalescence run their course without detectable alteration in adrenocorticosteroid secretion. There is a fall in the excretion of 17-ketosteroids as long as the patient is in the period of muscle rebuilding. This seems to be a nutritional effect; it resembles that seen in chronic starvation. However, the secretion or excretion of 17-hydroxycorticosteroids is not altered throughout this late period of convalescence, despite the fact that the patient is proceeding in a dynamic sequence. We have here, then, evidence that the later phases of surgical convalescence give no detectable alteration in the blood or urinary levels of 17-hydroxycorticosteroids.

In the adrenalectomized animal on constant doses of hormone, many of the expected changes occur without alteration in hormone dosage. Apparently the hormones are necessary for the occurrence of these changes, but the hormonal alterations are not essential in actually triggering them. It is important to observe, however, that one cannot rest his case by contending that the hormones are permissive. If they are permissive, what, then, actually initiates the bodily changes of surgical convalescence? The nonendocrine mediators are active, as already mentioned, but there are stimuli to the production of metabolic changes in the presence of constant hormone level and in cases in which the nonendocrine factors are minimal—that must be further investigated. Substances arising from the wound itself may be responsible for some of these changes, but we cannot yet establish this point.

In a recent publication[5] the interrelationships among the wound, the endocrine glands, and metabolism were briefly described. According to our present knowledge, these are complicated. Direct neural activation of endocrine alteration after wounding is well documented. This pathway involves the peripheral nerves, the spinal cord, the brain, the hypothalamus, the anterior pituitary, and the adrenal cortex. The four endocrine mediators—hydrocortisone, aldosterone, catechol amines, and antidiuretic substances—are capable of producing metabolic change after wounding, but they are not the only agencies.

Prolonged excessive catechol amine output may actually make the patient worse by causing severe tachycardia and vasoconstriction. Salt and water loading during the early phase may also make the patient worse, particularly if cardiopulmonary reserve is low. Thus there are two mechanisms to which this activation cycle reacts that make the effects of the wound more pronounced. A simple example of this vicious circle is found in the elderly patient with heart disease who undergoes a thoracotomy. Trauma increases heart rate, ultimately lowering forward output. Because of the wound, his pulmonary ventilation is less than perfect and anoxia and hypercarbia threaten him. Because of his heart disease, his postoperative tendency to load salt and water is marked, and if fluids are overadministered he will develop pulmonary edema, which in turn makes his ventilation worse, again initiating the cycle by further increasing anoxia, hypercarbia, catechol output, and tubular reabsorption of water and salt.

Finally, to complete this complex relation, there is good evidence that trauma, shock, and tissue anoxia alter the intermediary metabolism of steroid hormones. Whether this is all traceable to posttraumatic alteration in liver function is not known at this time. Some evidence suggests that the alterations in intermediary metabolism of hormones seen in surgical patients are not wholly attributable to either the liver or the kidney. Whatever their genesis, these alterations result in a more prolonged elevation of free hormone in the blood and the appearance of altered metabolites in the urine.

This confusing aspect of convalescent biology is therefore an arena of current controversy. Some hold that the aldosterone and corticosteroid secretory changes produce alterations in renal sodium excretion and in nitrogen and energy metabolism. Others contend that the corticosteroid factors are secondary, although they must be present and, indeed, at increased levels after trauma in order to make possible the changes shown, but that something else initiates the tissue changes. On the basis of present evidence it appears that the corticosteroids act largely in a permissive way, and that the 17-hydroxy fraction is important chiefly in maintaining blood pressure and vascular homeostasis, rather than in initiating alterations in nitrogen metabolism. I have seen many patients with very prolonged negative nitrogen balances whose corticosteroids were entirely normal after the first day. The importance of aldosterone on venal tubular sodium metabolism after trauma cannot be evaluated as yet, because the evidence is inadequate. Even here, however, it is clear that other factors are important, most especially the glomerular filtration rate, which is reduced in any extensive trauma or inhalation anesthesia.

The Relationship of Starvation to Metabolism After Injury

This subject has been a focus of interest since World War II. Peters wrote in 1944: ". . . administration of large excesses of protein (more than 100 to 125 gm. daily) immediately after injury is not indicated until some means is found to circumvent its immediate destruction; but throughout disease to provide generous supplies of food with adequate protein will insure against malnutrition."[6] Several studies have shown that when injury is not very extensive, nitrogen loss can be prevented by high food intakes. In more severe injuries, particularly when there is tissue necrosis, shock or sepsis, one observes an extent of nitrogen loss from 2 to 5 times greater than that seen in starvation alone. It is important again to emphasize that in certain types of infection the actual septic destruction of tissue can account for only a tiny fraction of the nitrogen loss. This is seen, for example, in a third-degree burn involving 25 per cent of the skin surface. When the amount of nitrogen in the destroyed skin is calculated, one finds that approximately 10 times as much nitrogen is excreted in the urine. The shrinking away of the gastrocnemius muscle, the quadriceps, the deltoid, and the trapezius, or any other muscle one wishes to observe, indicates that some mediator has taken the message of injury to these tissues, resulting in cellular catabolism. This happens despite forcing of very large intakes, and the question of mechanism or significance is by no means answered by the fact that infection is a feature of the case.

Nevertheless, the provision for maximal intakes soon after surgery certainly decreases the extent of lean tissue loss to an irreducible minimum, even though positive balance cannot be achieved. In my own experience, feeding drastically reduces the rate of fat oxidation. It seems as if the oxidation of body fat after injury occurs as a direct response to need for caloric energy. If this energy is supplied in sufficiently large amounts, fat oxidation is reduced. The loss of nitrogen is also reduced, but not to as low a figure as that seen in starvation, when injury is severe. In starvation, one can completely obliterate the loss of lean tissue and body weight by merely feeding a normal diet. After severe injury, far larger intakes are needed; in most clinical circumstances such intakes are not only impossible, but even dangerous when vomiting and aspiration are a hazard.

To summarize, trauma increases the loss of nitrogen on no intake and increases the intake required to maintain balance. Specifically, a normal person will just barely maintain balance on an intake of about 0.1 gm. of nitrogen and 20 calories/kg./day. After very severe injury, even intakes in the neighborhood of 0.4 gm. nitrogen/kg./day and 60 calories/kg./day will not maintain tissues intact.

Severe trauma seems to have an effect on body composition beyond the effects of starvation alone; however, starvation should not be tolerated for long, nor should it be permitted to be complete. Any food the patient will take and retain is to the good, although the patient who is fed too early and vomits the food obviously receives no benefit. If, as the desire for food becomes evident, the patient is not fed or cannot absorb food because of continuing gastrointestinal disease, then clearly his convalescence will be delayed. On the other hand, if he can take appropriate food freely at this time, he will regain his strength early in convalescence.

The Relationship of Starvation and Negative Nitrogen Balance to Healing of the Wound

Apparently the human body is prepared to carry through the early phases of convalescence living wholly on endogenous substrates mobilized from within the body. The wound passes through its early phases and achieves tensile strength in the absence of any intake. Vitamin C must be present in the tissues, but it need not necessarily be ingested during the time of the actual healing process; if the patient is not initially scorbutic, the wound will heal satisfactorily. A wound obviously accumulates protein substrates for tissue synthesis: collagen is formed, fibroblasts grow, and epithelium finally covers the wound—all without exogenous intake. Indeed, approximately one half of all surgical patients' wounds heal to the point at which anastomoses function and sutures are removed during a period of negative nitrogen balance.

This fact has often been misconstrued as indicating that negative nitrogen balance is somehow desirable or beneficial, which is not necessarily true. Nevertheless, it is important to realize that wounds usually do heal, even while nitrogen balance is negative.

There is a recurrent view in the literature that hypoproteinemia is inimical to wound healing. In approaching this matter one must differentiate three aspects sharply: (1) loss of body protein, which means muscle protein; (2) low concentration of albumin or other proteins in the serum, that is, hypoproteinemia; and (3) starvation, or specifically, protein starvation. The three are not necessarily found in combination. Frequently surgical patients who have lost by disease and starvation one quarter to one third of their muscle mass will have perfectly normal serum albumin concentrations; furthermore, their wounds will heal normally. Wound dehiscence occurs in starved patients, but it also occurs in patients who have lost very little, if any, weight. It is of interest, therefore, to inquire exactly what the effect of nitrogen metabolism is on wound healing.

One can find good evidence, not only from one's own surgical practice but also from the literature, that wounds heal well even in the presence of remarkably low serum albumin concentrations. Again, this is not to say that such concentrations are desirable, but merely to emphasize a realistic view toward surgical nutrition and to point out that hypoalbuminemia per se cannot be specifically identified as a hindrance to wound healing. Although a wound needs many things from the body, serum albumin does not appear to be one of them. The patients in whom wound healing is most often good despite hypoalbuminemia are those with liver, heart, and kidney disease. These patients are vulnerable to many complications of surgery, including pulmonary and peripheral edema, ascites, and infection, yet actual tensile knitting of their wounds may be normal.

Starvation alone is not an important predisposing factor in infection; bacterial contamination and poor hygiene are far more important.

The case of the starved rat has considerably clouded this issue. The protein-deprived rat has been commonly referred to as "hypoproteinemic." Whether the animal is or not depends largely on the degree of water and salt loading and, of course, on the animal's actual serum protein concentration. Time relationships of starvation in the rat are also very important. Of all beasts, the rat has almost the least resistance to starvation. After a few days of complete starvation the rat is a very sick animal, eating its own feces and its cage mates, whereas a human being after many weeks of semistarvation is still able to make the most remarkable physical efforts for survival, escape, or even convalescence.

Negative nitrogen balance is not inimical to wound healing; most wounds heal during nitrogen loss. However, two points of positive correlation are of great interest. First, a patient's nitrogen balance rarely begins to move from negative to positive until the wound, if an open one, has nearly healed. If the wound has large open or granulating surfaces, mobile fractures, or smoldering infection, the balance will not become positive. An unhealed or open wound tends to retard biochemical convalescence and to maintain the catabolic phase. In its later aspects, when infection is present, this is the situation I have called septic starvation. If this situation becomes so prolonged and chronic, without sepsis, that the patient finally does show a positive nitrogen balance although the wound remains unhealed, one then sees the late nonunited fraction with pseudoarthrosis, or very late—3 to 6 months—unhealed burns with indolent, edematous granulations in which all signs of healing have ceased. In both instances major trauma is required to raise the wound again to the high biological priority it formerly held within the organism.

The second point of correlation has to do with the significance of positive nitrogen balance. The positive nitrogen balance of later surgical convalescence is wholly devoted to restoring nitrogen to the lean tissues, chiefly skeletal muscle, which had formerly yielded this nitrogen. A few calculations are of interest here. In the first three weeks after extensive operation or injury, the amount of nitrogen mobilized approximates 300 gm., which represents about 9 kg. of wet lean tissue. This amount of tissue, which is more than 10 per cent of the patient's initial body weight, is too large to be identified with the tissue destroyed in the wounded area itself, as already mentioned in the section on nonendocrine mediators. Clearly, this nitrogen comes from muscle. Skeletal muscle is the only source of protein in the body sufficiently large to yield this much nitrogen; moreover, the muscle masses clearly and measurably shrink. The viscera do not yield this nitrogen; the heart, the liver, the gut, and the lungs do not shrink after injury. In fact, certain viscera, particularly the heart and the liver, may become larger after trauma. It is apparent, therefore, that peripheral skeletal muscle is the nitrogen donor for the body and the beneficiary of positive nitrogen balance during recovery.

It is to the re-education and rehabilitation of skeletal muscle that most of conventional physiotherapy is directed. For this reason, the intake of the patient, his external work output, and the degree of muscular regrowth needed must be taken into account in planning the physical therapy of the individual surgical patient. Work output should not be significantly higher than caloric intake if the patient is to continue to grow normal muscle bellies, which will ultimately make him strong.

It is tempting to associate loss of nitrogen from the muscle mass with decreased muscular strength. This has been studied, and as yet no conclusive result has been obtained. The change within muscle must be that of lost tissue within cells, rather than the actual death of cells, in the course of post-traumatic catabolism. The neuromuscular connection remains intact, and this implies the maintenance of all the muscle cells intact. Muscular strength is decreased immediately after trauma, but it is difficult to evaluate because of considerations of motivation and discomfort. As the patient regains nitrogen in his muscles he also regains strength, and it is that resumption of strength and painless motion that forms the basis of late convalescent rehabilitation.

Summary

From the moment of injury, and even before, through the return to normal health, we see a dynamic sequence in the surgical patient, who is changing every day. These changes are found in alterations of local tissue in the wound, in body composition, bodily metabolism, visceral function, and the endocrine glands. The underlying sequence is that of an early period of lean tissue destruction and fat oxidation with extracellular conservation, which gives way to diuresis and is followed by resynthesis of muscle and, finally, redeposition of fat.

Whether, and to what degree, these changes are related to the endocrinology of trauma, we do not know. Despite the current interest in wound endocrinology, there are many nonendocrine stimuli to diffuse bodily change after injury. These must not be ignored, since they are the basis of sound wound surgery. Many metabolic changes occur without alteration in adrenal function, and there are many changes in the intermediary metabolism of adrenal hormones after injury. It is our conviction that the 17-hydroxy fraction is more important to vascular homeostasis than to bodily metabolism.

The gain of strength and muscle function that occurs in the convalescent and physiotherapeutic period is associated with nitrogen gain. Whatever the function of diet prior to this, we know that it is needed here in late regrowth, and that dietary intake must be in excess of work requirements if muscle is to be rebuilt and fat redeposited.

Much of this convalescent sequence is basic to the organism. The Darwinian concept of survival of the fittest truly finds its expression in the biological sequences involved in survival after injury. This basic property of the organism is not easily changed or accelerated by minor actions of the surgeon. Meddlesome treatment is often harmful, but neglect, especially of the clinical implications of this sequence, is equally undesirable. Understanding of the normal physiology, biochemistry, and metabolism of convalescence is basic to good surgical care.

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METABOLIC RESPONSE TO SURGERY: SYSTEMIC, ADRENAL, AND COMPOSITIONAL*

By James D. Hardy

Department of Surgery and University Hospital, University of Mississippi Medical Center, Jackson, Miss.

Introduction

As the general pattern of the metabolic response to surgery has unfolded, it has become increasingly clear that all organs and all cells participate. The purpose of this paper is to examine certain of the more prominent aspects of this response, with particular emphasis on: (1) the general systemic response, (2) the hormonal content of adrenal vein blood taken at laparotomy, and (3) the changes in body composition after surgery.

Initiating and Feedback Mechanisms[1, 2]

The metabolic response to surgery must have a beginning and an end. It is accepted that the physiological response to surgery is initiated by the injury itself, but little attention has been devoted to a consideration of what forces, neural or humoral, may come into play to reverse this metabolic response to surgery and to restore the normal state. For example, it is agreed that a surgical incision releases neurohumoral impulses that cause a release of ACTH by the pituitary, to increase adrenocortical secretion. But what are the forces that arise, in time, to return the adrenal function to a normal level? Does the rise in the plasma corticoid level act upon the anterior pituitary to suppress the release of ACTH? Again, what factors cause the weight lost following surgery to be regained—and to a level more or less normal for the subject in question? Such damping or opposing factors are termed feedback mechanisms. Physiologists are deeply interested in these mechanisms, the physiological antagonists or counterbalancing forces that tend always to aim toward readjustment to the steady state. It is reasonable to suppose that feedback mechanisms must exist, in order gradually to retard and eventually to reverse the segments of the physiological response to surgery. At the present time, however, we are largely ignorant of the nature of these mechanisms.

Systemic Response

Figure 1 shows some of the more readily documented physiological alterations that follow major surgery. While not all the illustrated changes can be found in every patient, most of them will be encountered for, up to a point, the magnitude of the physiological response is proportional to the magnitude of the injury, and the pattern of the response is of a somewhat uniform type. The chronically ill patient exhibits a less marked metabolic response to a given operation than does the previously healthy subject.

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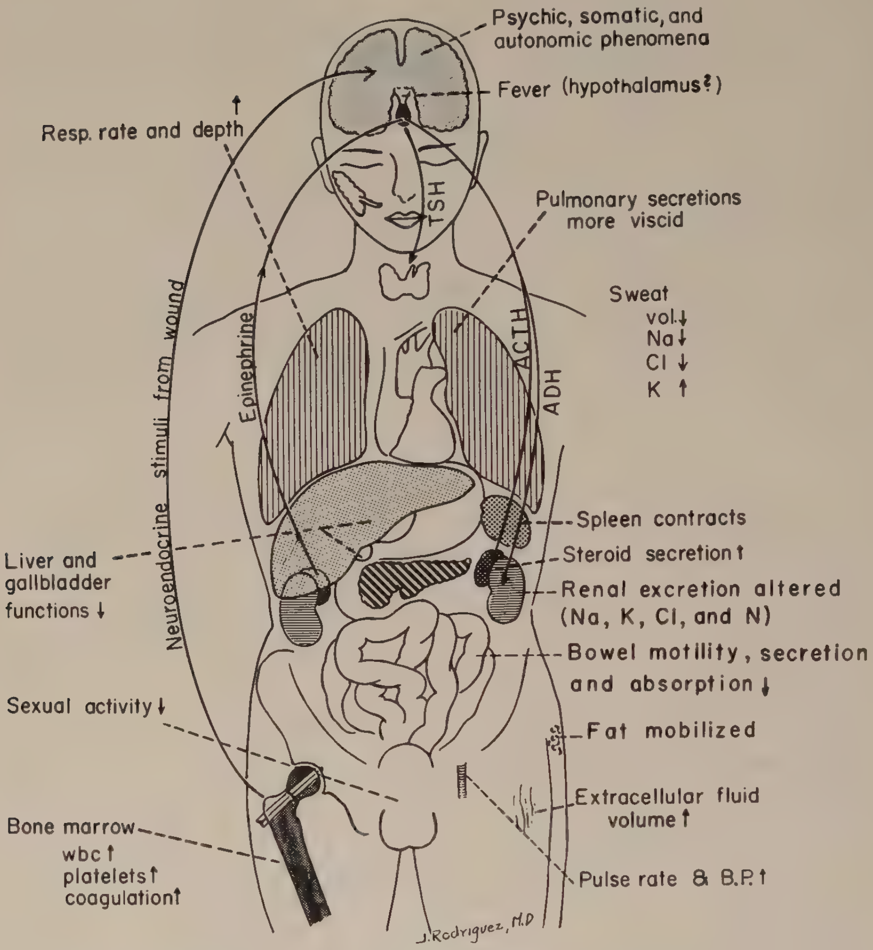
Psychic, somatic, and autonomic phenomena
Fever (hypothalamus?)
Resp. rate and depth ↑
TSH
Pulmonary secretions more viscid
Sweat
vol. ↓
Na ↓
Cl ↓
K ↑
Neuroendocrine stimuli from wound
Epinephrine
ACTH
ADH
Spleen contracts
Liver and gallbladder functions ↓
Steroid secretion ↑
Renal excretion altered (Na, K, Cl, and N)
Bowel motility, secretion and absorption ↓
Sexual activity ↓
Fat mobilized
Extracellular fluid volume ↑
Bone marrow
wbc ↑
platelets ↑
coagulation ↑
Pulse rate & B.P. ↑
J. Rodriguez, M.D

FIGURE 1. Systemic reaction to surgery. All organs and probably all cells participate in the metabolic response to surgery. Reproduced by permission from Hardy.[3]

For the sake of order and convenience, let us follow the diagram in FIGURE 1 from the head downward, considering ways in which the functions of various organs are altered following anesthesia and operation. The endocrine response is described last, since it leads into a consideration of the adrenal response, which is discussed in the second section of this paper.

Throughout this consideration of the various systems, it should be kept in mind that the three great coordinating systems of the body are the nervous system, the circulatory system, and the endocrine system.

The Nervous System

As a principal motivating and integrating force in the human organism,[4, 5] the nervous system must be accorded a prominent role in the systemic response to surgery. We are all familiar with the emotional problems experienced by the patient facing a surgical procedure, and with the different type of reaction he exhibits during the immediate postoperative period. There is apprehension before the operation, a marked change in mood, and a reduction in motivation immediately after surgery, and thereafter a steady return of interest and enthusiasm as the metabolic phenomena that constitute convalescence restore mental vigor and physical strength. Throughout history, great writers—including Shakespeare, Tolstoi, and Hemingway—have vividly portrayed the influence of disease upon the human mind. Moreover, all of us are familiar with the ways in which a patient's will to live can apparently affect the quality and the rate of his convalescence.

Specifically, then, what are some of the connections between the cerebral cortex and the ultimate visceral end-organs that enable the mind[6] to influence the visceral reactions, which, in turn, implement convalescence?

That a continuous neurohumoral pathway links the cerebral cortex and the most remote viscera is no longer a matter of conjecture. There has been increasing recognition of the existence of widespread autonomic representation at the cortical level in both man and animals, and various data have been advanced to elucidate a functional interrelation between the two systems.[7]

The limbic system of the brain, consisting of certain important subcortical structures, serves as a conducting unit between the cerebral cortex and the hypothalamus, and thence to the pituitary body and the autonomic nervous system. As we know, the hypothalamus represents a key integrative center for the autonomic nervous system. It receives impulses from other parts of the brain, including the "mind," and it transmits these impulses to the viscera. Indeed, it would be difficult to overestimate the importance of the hypothalamus and adjacent nervous structures in the over-all systemic response to anesthesia and operation. For example, the hypothalamus, with its galaxy of surrounding elements and neural connections, has been accorded a role in the following physiological activities, among others: (1) regulation of pituitary secretion; (2) general maintenace of homeostasis or the "steady state"; (3) carbohydrate, protein, and fat metabolism; (4) regulation of body temperature; (5) water and salt metabolism; (6) waking and sleep; (7) appetite; (8) gastric, intestinal, pancreatic, and biliary functions; and (9) respiration.

Clearly, the nervous system is of primary significance in the physiology of convalescence.

The Cardiovascular System

The general importance of the circulation as a coordinating mechanism has been mentioned. In addition, there are certain specific changes in cardiovascular activity that occur in association with major surgery.

Preoperatively, perhaps the most striking and familiar findings referable to the circulation are the increases in pulse rate and, to a lesser extent, in blood pressure, which are due to apprehension. This may be due in part to an increased secretion of epinephrine by the adrenal medulla, but it is also due to impulses mediated by the sympathetic accelerator nerves to the heart through pathways leading from the cerebral cortex, since this apprehensive response[8] can also occur in adrenalectomized patients. In general, there is an increase in the rate and force of cardiac action, an increase in cardiac output, and a mild rise in blood pressure prior to surgery. Following operation, if nothing has occurred to cause shock, there may be a continuation of such changes. During operation the anesthetic may dampen the sympathomimetic response.

The hypertensive response to surgery. Among patients one may find occasionally an unusually marked and sustained hypertensive response to operation or other trauma. We have encountered this reaction following burn injury and after resection of a coarctation of the aorta. Howard *et al.*[9] reported this finding in wounded soldiers. In essence, a fairly marked hypertension may be associated with rapid heart rate, circumoral pallor, and sweating, which may continue for several days. In the case of wounded soldiers it persisted until general anesthesia was administered. The full explanation of this hypertensive response is not yet available, but recent studies have indicated that its appearance, at least following resection of coarctation of the aorta, may be due to the secretion of excessive amounts of the catechol amines by the adrenal medulla.[10] Howard *et al.*[9] obtained confirmatory evidence for this explanation by ascertaining that the administration of hexamethonium abolished and Regitine reduced this hypertension in the wounded man.

Circulatory instability. The quality of a patient's postural reflexes, as elicited by blood pressure and pulse rate changes upon his standing up or lying on the tilt table, may be impaired during early convalescence. Mayock *et al.*[11] concluded from their study of this phenomenon that it was useful as a yardstick in determining the progress of convalescence. Abrupt change to the upright posture was better tolerated by those patients whose convalescence was not impaired. It was also found that patients whose nutrition was vigorously supplemented during the early postoperative period exhibited less marked intolerance to the upright posture than did those who had not been aggressively fed during the early postoperative period. I must point out, however, that for the time being we have largely abandoned efforts to force food upon patients during the first 48 hours after major surgical procedures. We are not convinced that it is effective in enhancing the total quality of convalescence, in most instances.

The Respiratory System

The ways in which the respiratory system reacts to a distant incision have not been as closely studied as have the responses of certain other systems. Nevertheless, it has been observed that bronchial secretions may be more viscid. Moreover, following major surgical procedures various degrees of pulmonary atelectasis may result in defective pulmonary ventilation and oxygenation of the blood. This fact has long fostered an insistence upon deep breathing and coughing in the early postoperative period, plus the use of nasotracheal catheter suction to remove secretions and to prevent bronchial occlusion.

Although accurate studies of pulmonary function are difficult during the early postoperative period, the recent interest in measuring pulmonary compliance[12] during and after surgery indicates that there is, in fact, a diminished elasticity of the lung following most major surgical procedures, particularly those that involve the thorax. The measured vital capacity may also be reduced, although such a measurement may not be trustworthy because of the influence of incisional pain upon the patient's respiratory efforts.

Various types of brain damage may result in what appears to be abnormally easily produced pulmonary edema, re-emphasizing the relationship between cardiopulmonary function and the central nervous system. Moreover, evidence has been advanced that total autonomic (sympathetic and vagal) denervation of the lungs results in apnea, despite the fact that the phrenic nerves are still intact. It has usually been thought that normal respiration is stimulated by a rhythmical activity of the respiratory center in the brain, and that afferent impulses from the thorax are of secondary importance and not absolutely essential.

The Gastrointestinal Tract

Alimentary secretions. Prior to surgery the mouth may be dry from apprehension, even if atropine has not yet been given. Following surgery a change takes place in the electrolyte composition of saliva, the volume of gastrointestinal secretions that can be aspirated with a Miller-Abbott or a Levin tube is diminished,[13] and rates of intestinal absorption of certain foodstuffs are altered in the early postinjury period.[14]

Intestinal motility. The ileus that follows most surgical procedures, even those that do not involve the gastrointestinal tract, is a familiar phenomenon. Nevertheless, barium placed in the stomach or duodenum does progress steadily down the intestinal tract, even during the period when one might expect that the effects of ileus were at their height. Therefore, it may be that what one hears with the stethoscope does not accurately reflect the propulsive ability of the intestine, certainly for dilute barium. Even so, the return of bowel sounds and the passage of flatus on the second or third postoperative day usually mark the end of an initial phase of convalescence.

Appetite. The patient usually has no desire for food for several days following a major operation. The anorexia is encountered whether or not the surgery involves the gastrointestinal tract. It is probably mediated by way of the hypothalamus and surrounding structures.[15] This problem will be discussed further in relation to the reconstitution of normal body composition following the depletive effect of major surgery.

Liver, Gallbladder, Spleen, and Pancreas

The liver has many different functions, and it is not a simple matter to demonstrate definite postoperative alterations in all of these activities. Nevertheless, studies over the years have indicated various minor alterations in the function of the normal liver following the assault of anesthesia and operation.[16] It is to be expected further that, as the tests of hepatic physiology become more sensitive and precise, additional postoperative alterations in liver activity will be identified. Certainly we know even now that the patient with borderline hepatic reserve may be unable to supply many of the requirements of a good metabolic response. Indeed, if overt liver failure develops following surgery, various normal hepatic activities will quickly become apparent through their absence.

It has been reported that gallbladder function is abnormal following major trauma.[17]

The spleen has long been known to participate in the physiology of stress in animals, since the release of epinephrine and norepinephrine results in a contraction of this organ to force additional red cells into the general circulation. However, the increment in red cell mass supplied by splenic contraction is probably not significant in man. The more subtle role of the spleen with respect to the regulation of the numbers of platelets, red cells, and white cells following operation is doubtless more important than is splenic contraction. In concert with the bone marrow, the spleen has the role of regulating the numbers of various cellular elements in the peripheral blood, and it is characteristic after major surgery to find an increase in the white cell count and in the platelet count. This increase in the platelet count may be responsible, in part, for the increase in the coagulability of the blood following surgery. Whether the spleen regulates the various numbers of the cellular elements in the peripheral blood by means of destruction of excess numbers of these cells within its confines, or whether it primarily regulates the number of these cells by secreting a hormone that regulates the production of blood cells in the bone marrow is not relevant to this discussion.

It is frequently alleged that splenectomy causes more than the usual mild postoperative rise in body temperature. We are investigating this question in our laboratory.

The precise role of the participation of the pancreas in the reaction following operation has not been as well documented as have the activities of certain other organs, particularly because there is no ready measurement for insulin concentration in the circulating blood. Nevertheless, there is much indirect evidence that pancreatic activity is altered following surgery. For example, many patients exhibit stress glycosuria. To be sure, this may be due primarily to an increase in the secretion of adrenocortical steroids, but it doubtless also reflects an interrelationship with the amount of insulin being secreted, or an unusual resistance to such insulin. However, the site of action of insulin and that of the glucocorticoids need not be the same and, very likely, it is not.[18, 19]

As regards the exocrine function of the pancreas, the amylase level has been found to be variously altered following trauma, being either elevated or diminished. It is probable that the volume of pancreatic secretion is diminished in the early postoperative period, along with the diminished volume of secretion of the other organs that pour fluid into the upper gastrointestinal tract.

Muscle, Bone, and Kidney

Muscle. There is abundant evidence that the muscles do, of course, participate in the metabolic response to surgery. This is reflected in the increased excretion of nitrogen, potassium, and creatinine that is commonly observed.[20]

After all, the muscles constitute a large portion of the lean body mass, and it would be most surprising if a considerable segment of the metabolic activity following surgery did not occur in these structures. The muscles also contain a large percentage of the total body water, which of course includes extracellular fluid and plasma volume. Therefore, aside from noting that the actual strength of muscular function is diminished for variable lengths of time following a major operation, at this particular point we need not consider further the various ways in which the muscles, with their nitrogenous, water, and electrolyte composition, contribute to the postoperative phenomena commonly observed.

Bone. It is certain that the stress participation of the skeletal system, which does indeed represent a considerable portion of the body mass, will come to be more clearly defined. Well-established evidence indicates that the bones are involved in the metabolic reaction to trauma, particularly to operations directly involving bone. In 1932 Cuthbertson[21] showed that the fracture of a long bone resulted in a prolonged nitrogen wastage in the urine. This was associated with an increased excretion of calcium.

It has been noted that the metabolic response to major fractures is likely to exceed in duration the response to operations that involve only soft tissue, such as that of gastric resection. One might assume, therefore, that the healing process in bone, which goes forward more slowly, continues to initiate hormonal or neural stimuli that affect some segments of the metabolic activity for weeks or even months.

Of particular interest to students of body fluid physiology has been the question of the extent to which the common extracellular cations can be stored in bone. For example, the lowered plasma or extracellular sodium levels noted postoperatively—the physiological "low sodium syndrome" following major trauma—may be due to the migration of the sodium into bone or other organs.[22] On the other hand, it is conceded that the reduced plasma sodium level may be due in part to an augmentation of the extracellular fluid volume, with a consequent dilutional effect on the sodium contained in the extracellular space. In point of fact, however, the mechanism of the various low sodium syndromes[23] is not always readily explained.

Finally, concerning the physiology of bone, it should be noted that the use of radioisotopes makes possible the demonstration of a surprisingly rapid turnover in the various components of osseous tissue. For many years bone was thought to be a relatively inert structure whose molecular composition was indefinitely maintained without change, with relatively little turnover in the atomic constituents.

The kidney. The participation of the kidney in the metabolic response to surgery has been the subject of innumerable investigations over the past twenty years, and this fascinating story continues to unfold. Although renal function is obviously affected by alterations in the circulation per se, it is also profoundly influenced by factors that act upon renal tubular reabsorption. Moreover, these latter factors, which are chiefly hormonal in nature, produce the more conspicuous renal excretory changes in the postoperative patient. The paper by Francis D. Moore in this monograph reviews several facets of postoperative renal function; consequently it is sufficient merely to touch upon the subject here. There is an early reduction in the volume of urine secreted and a change in its electrolyte composition. In general, the excretion of potassium tends to increase and the excretion of sodium to decrease. These changes have been thought to be due to the interplay between the antidiuretic hormone of the posterior pituitary and the adrenocortical steroids[24] and, in particular, aldosterone.[25, 26] In collaboration with Louis L. Sulya of the Department of Biochemistry at the University of Mississippi Medical College, we too have found a consistent postoperative inverse correlation between an increased excretion of aldosterone and a decreased excretion of sodium. Sulya employs the paper chromatography method of Simpson and Tait,[27] with minor modifications.

The Endocrine System

The neuroendocrine response[28] has been considered in detail elsewhere in this monograph. Suffice it to note here that the injury itself initiates an increased activity of the anterior pituitary,[29, 30] posterior pituitary,[31] adrenal cortex, adrenal medulla and, very likely, of other endocrine organs.[32] The possible effect of operation upon thyroid activity has been studied in many laboratories, but whether this activity is increased or decreased remains unsettled. To my mind it is probable that, with more refined methods of evaluation, alterations in the rate of secretion of one or more of the several active thyroid principles will be demonstrated. This question is being examined here at the University of Mississippi Medical Center by means of paper chromatography.

In summary, the total nature of the involvement of various body organs in the physiological response to major surgery should be emphasized.

ADRENAL RESPONSE

Urinary Excretion of Corticoids and 17-Ketosteroids and Total Eosinophil Counts

The adrenocortical response to many types of stress has been studied intensively during the past decade. Whereas for a time the total eosinophil count was used as an indicator of alterations in adrenocortical activity, it was not long before methods for measuring the excretion of corticoids and 17-ketosteroids in the urine were available to many investigators and, not long thereafter, it became possible to measure plasma levels of 17-21-hydroxycorticosteroids. FIGURE 2 shows the changes in the urinary excretion of corticoids[33] and 17-ketosteroids[34] in a young man who had three stages of the standard posterolateral thoracoplasty for cavitary pulmonary tuberculosis.[35] These data not only reflect the typical response of an individual in fairly good general health to a single operation, but they also afford an opportunity to examine the effects of multiple operations in the same individual. The most notable findings regarding the excretion of 17-ketosteroids were, first, that there was a gradual decline in the level of 17-ketosteroid excretion in the urine over the course of the three operative procedures, which were spaced at three-week intervals. The lowest level was observed several days after the third opera-

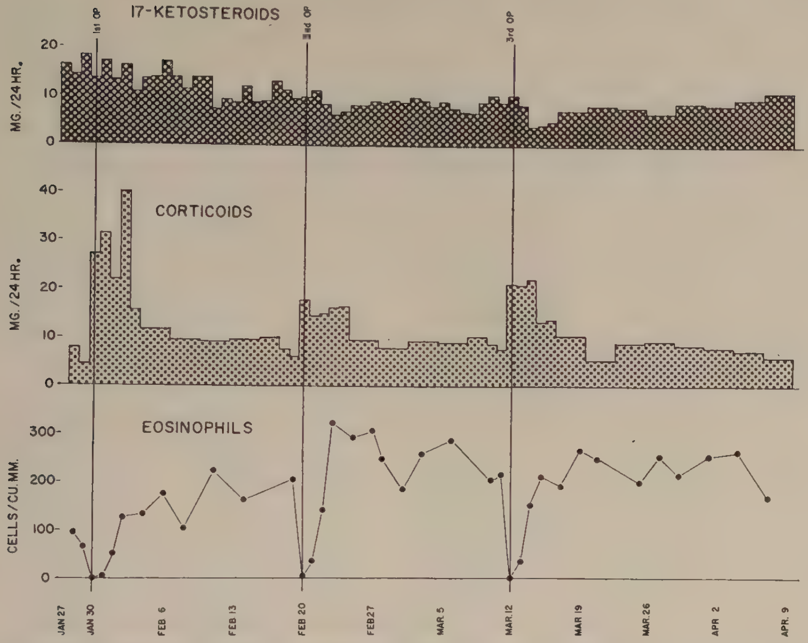

FIGURE 2. Effect of three-stage thoracoplasty on the eosinophil count and urinary excretions of corticoids and 17-ketosteroids in a robust young male patient, A.D. The excretions of corticoids increased and the total eosinophil count decreased following each operation. The level of 17-ketosteroid excretion gradually declined over the three operative stages, to rise slowly during convalescence. Reproduced by permission from Hardy.[35]

tive stage. Thereafter there was a gradual return toward normal levels over the next month of convalescence. A decline in sexual interest and activity is a conspicuous feature of early convalescence, and the return of normal function is frequently correlated with a return in the general sense of well-being. The urinary excretion of 17-ketosteroids, which usually declines following a serious illness or major operative procedure, may be useful as a gross yardstick of the progress of convalescence.

Second, the corticoid excretion was found to be increased by each operation and to be elevated significantly for at least three weeks thereafter in this particular patient, who had operations that involved dividing a considerable muscle mass as well as the resection of portions of various ribs. However, one month after the third and final stage, the urinary excretion of corticoids had returned essentially to the control levels obtained prior to the beginning of surgery. As indicated previously, the duration of the increase in the urinary excretion of corticoids following major operations is affected considerably both by the type of operation performed and by the general health of the patient prior to surgery. Elderly patients and patients who are chronically ill frequently exhibit a low normal level of corticoid excretion preoperatively, and they do not exhibit as marked an increase in the level of this excretion following surgery as do healthy young subjects.

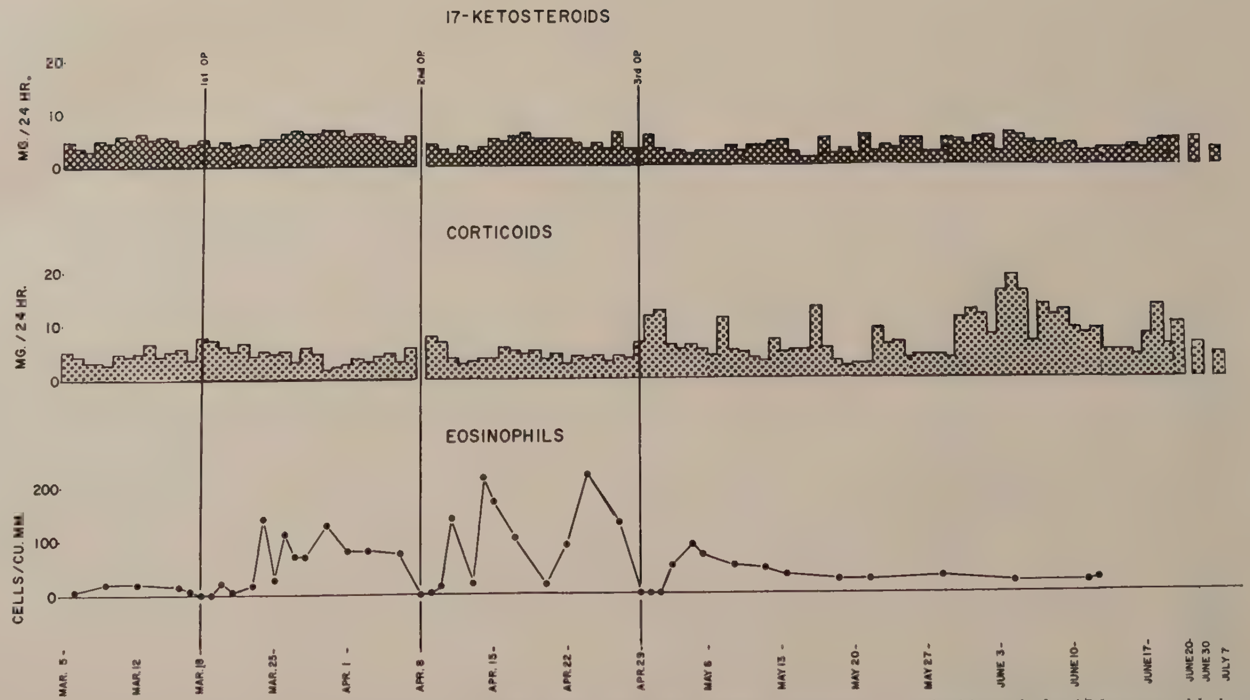

FIGURE 3. Effect of three-stage thoracoplasty on the eosinophil count and urinary excretion of corticoids and the 17-ketosteroids in a chronically ill male patient, R.P. The level of excretion of corticoids was at a low normal value preoperatively, and it rose only slightly following the operations. The level of 17-ketosteroid excretion was low throughout the four months of the study, reflecting chronic illness. The total eosinophil counts were near zero before and after the series of operations, although the rebound phenomenon was present after each stage. Reproduced by permission from Hardy.[35]

The total eosinophil counts of the patient A. D. shown in FIGURE 2 exhibited the usual fall to zero with surgery and the subsequent rebound phenomenon usually observed in individuals in fairly good general health.

In FIGURE 3 the effects of chronic illness are reflected in the excretion of 17-ketosteroids and corticoids, and in the total eosinophil counts.[36] Whereas the robust young male showed a sharp increase in the excretion of corticoids following each operation, this patient, R. P., who was chronically ill with far-advanced pulmonary tuberculosis, exhibited relatively little change in the level of corticoid excretion after each operation, although there was a modest increase after the third procedure. The urinary excretion of 17-ketosteroids was low throughout the entire period of the study, which covered the interval from March 5 through July 7. Finally, whereas the "healthy" patients exhibited a marked fluctuation in the total eosinophil count following each operation, beginning with relatively high levels preoperatively, the patient shown here exhibited a total eosinophil count that was usually near zero prior to the first operation, showed relatively little rebound after the various stages of the thoracoplasty, and returned promptly to a value continuously near zero throughout the remainder of the study. This low total eosinophil count was thought to reflect the degree of his chronic illness, regardless of the operative procedures that were performed.

17-21-Hydroxycorticosteroids in Peripheral and Adrenal Vein Blood in Man

Stimulated by the studies by Hume and Nelson[37] of adrenal vein blood in dogs, we undertook to study the various hormonal elements of adrenal vein blood in man which was obtained at laparotomy performed for various reasons. The left adrenal gland lies beneath the tail of the pancreas. It is a simple matter to divide the gastrocolic ligament, incise the peritoneum along the inferior margin of the pancreas, retract the jejunum downward at the ligament of Treitz, retract the pancreas upward with a Deaver retractor, expose the left renal vein, and then readily identify the left adrenal vein and visualize the left adrenal itself as it lies against the aorta and medial to the upper pole of the left kidney. This exposure is shown in FIGURE 4. Although the central adrenal vein does not constitute the entire venous outflow of the adrenal, under normal circumstances most of the venous blood of the left adrenal does return to the left renal vein through the left central adrenal vein. Therefore, by collecting the entire flow of the left adrenal vein over a timed interval one can not only determine the concentrations of various hormones in this blood, but also achieve at least an approximation for the rate of production of a particular hormone per minute and offer an estimate for the production per twenty-four hours.

17-21-Hydroxycorticosteroid levels.[38] FIGURE 5 shows adrenal plasma levels of 17-21-hydroxycorticosteroids in ten patients, along with levels of free and conjugated 17-21-hydroxycorticosteroid levels in peripheral blood.[39, 40] It was shown by Romanoff *et al.*[41] that hydrocortisone constitutes more than 85 per cent of the total steroid secretion of the adrenal cortex in man.

It is important to determine both free and conjugated hydrocortisone levels. The conjugated form presumably represents a moiety rendered at least tem-

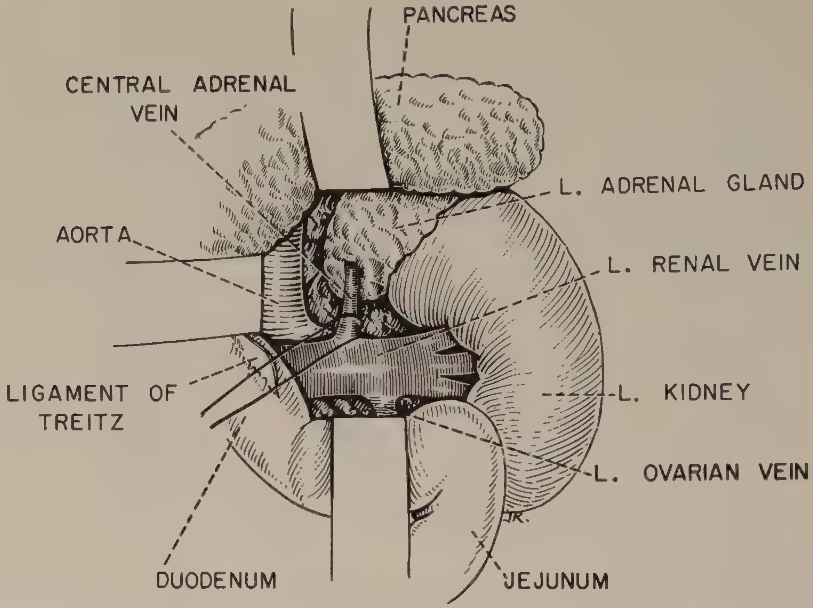

Figure 4. Surgical exposure of the left adrenal gland. Reproduced by permission from Hardy and Turner.[38]

porarily inactive by the liver. Certainly a large amount of free hydrocortisone is rapidly converted into conjugated hydrocortisone. Whether the reverse is true is not certain. Various workers have suggested that the metabolism of a given weight of hydrocortisone may be altered in stress, since a given amount may be rendered more active metabolically.

Preoperatively, the free and the conjugated forms of hydrocortisone in peripheral venous blood were approximately equal, and each was less than 10 gamma/100 ml. During operation the peripheral plasma levels altered, that of the free hydrocortisone increasing over that of the conjugated hydrocortisone, the values in gamma percentage being approximately 25 and 18, respectively. During operation, the sample of adrenal vein blood, which was obtained almost simultaneously with one of peripheral blood, showed an average level of free hydrocortisone of 224 gamma per cent, as compared with an average level of conjugated hydrocortisone of 125 gamma per cent. One might well question the validity of such a high level of conjugated hydrocortisone in adrenal vein blood. However, we have obtained limited evidence to show that some conjugation can occur in blood outside the liver. Such extrahepatic conjugation is apparently achieved by means of enzymes formed in the liver, however, for this activity was abolished by hepatectomy. In any case, this extrahepatic conjugation is very small. M. D. Turner of our Medical Center is continuing his study of this question, using paper chromatography to identify more precisely the various fractions of the adrenocortical secretion.

Four hours after surgery the level of free hydrocortisone in peripheral blood

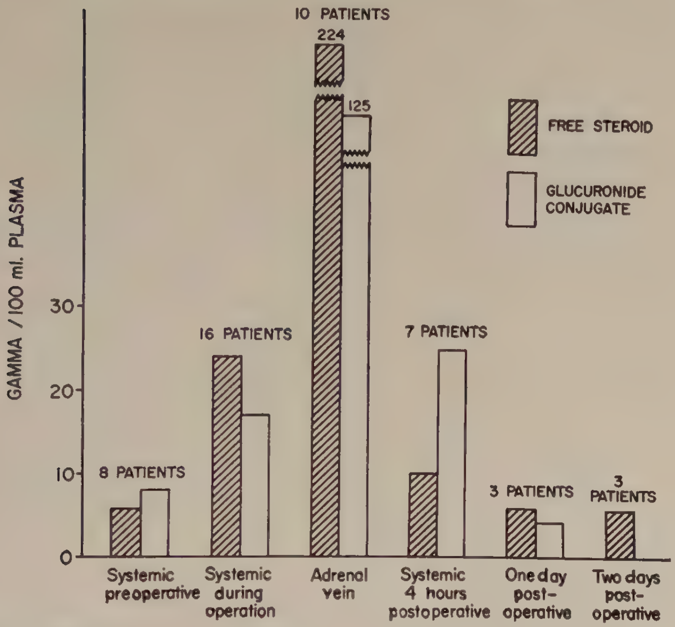

FIGURE 5. Effect of surgery on adrenal vein and systemic hydrocortisone plasma levels. The expected rise in the hydrocortisone levels in peripheral plasma is demonstrated during and after surgery. The relatively high level of the conjugated fraction in peripheral blood four hours after operation presumably reflected rapid conjugation, by the liver, of the free hydrocortisone in adrenal vein blood. Reproduced by permission from Hardy and Turner.[38]

had diminished sharply, but the level of conjugated hydrocortisone at this time was more than twice the level of the free moiety. Presumably, time had permitted conjugation by the liver of the large amounts of free hydrocortisone secreted during operation. By the end of 24 hours the peripheral plasma levels had returned to control values.

TABLE 1 gives estimates of the rate of hydrocortisone secretion by both adrenals during stress and during a resting state in patient J. H. On the basis of timed adrenal vein blood samples, it was estimated that, during operative stress, the rate of secretion of hydrocortisone, both free and conjugated forms, was approximately 77 gamma/min. A sustained secretion by both adrenals at this rate would afford a value of 111 mg. hydrocortisone/24 hours. By making certain assumptions relative to the level of hydrocortisone in adrenal vein blood as compared with the rise in peripheral plasma induced by surgery, it was estimated that the rate of hydrocortisone secretion during the normal resting or nonstressed state might be on the order of 24 gamma/min. or 34 mg./24 hours, red cell content of hydrocortisone not being considered. Red cells contain a fraction of the total blood hydrocortisone, and doubtless an increment or correction for red cell content of hydrocortisone should be added, resulting in a value somewhat greater than 34 mg./24 hours for hydrocortisone secretion in the resting state.

TABLE 2 shows the values obtained for peripheral and adrenal vein hydro-

TABLE 1
HYDROCORTISONE OUTPUT*
(Based on Plasma Content†)

	Gamma/min.	Mg./24 hr.
Operative stress	77	111
Resting	24	34

* Estimation of the resting secretion was made on the basis of adrenal vein samples obtained at laparotomy, as related to the rise in peripheral plasma levels during surgery. Reproduced by permission from Hardy and Turner.[38]

† Red cells may contain approximately 25 per cent of the total blood hydrocortisone.

TABLE 2
GASTRIC RESECTION FOR GASTRIC ULCER: ADRENAL ATROPHY DUE TO PROLONGED HYDROCORTISONE THERAPY

	Plasma hydrocortisone levels (gamma percentage)	
	Free	Conjugated
Peripheral blood before operation	0	0
Peripheral blood during operation	0	85
Adrenal blood during operation (receiving hydrocortisone I. V.)	10	5
ACTH infusion test postoperatively		
Control	0	0
4 hours after ACTH	1	0

cortisone levels in a man, W. G., who had been treated with hydrocortisone for arthritis over a period of many months. Although he was nominally covered with hydrocortisone during operation for bleeding gastric ulcer, the coverage was probably inadequate. To our surprise, when the steroid analyses had been run, the preoperative level of hydrocortisone in peripheral blood—before hydrocortisone coverage had been started—was zero. During operation with steroid coverage, the level of free steroid in peripheral blood was still zero, but the level of conjugated hydrocortisone was 85 gamma per cent. The free and conjugated levels in adrenal vein blood were 10 and 5 gamma per cent, respectively. I have no explanation for the fact that the total level of conjugates in adrenal vein blood did not more nearly approach that of peripheral blood, but the level of free hydrocortisone was of interest; in normal subjects the level of free hydrocortisone in adrenal vein blood has usually exceeded 200 gamma per cent. The normal architecture of the left adrenal gland was found to be almost completely destroyed when the gland was visualized at surgery. Subsequently, during late convalescence, almost no response was obtained to ACTH infused intravenously.

Clearly, the promiscuous use of cortisone and related steroids in the treatment of various medical diseases represents a serious hazard if these patients must later undergo surgery.

*Plasma 17-ketosteroid levels.** FIGURE 6 shows representative values obtained for the plasma levels of 17-ketosteroids in peripheral vein blood, adrenal vein blood, and ovarian vein blood.[44] The peripheral vein concentration was on the order of 100 gamma per cent before, during, and following surgery. Thus, the operation had little effect upon the 17-ketosteroid levels of peripheral plasma. In the adrenal vein blood and in ovarian blood the levels were 150 gamma per cent and about 225 gamma per cent, respectively. Therefore, "androgenic" substances giving the 17-ketosteroid reaction were present in substantially higher concentration in adrenal vein blood and in ovarian vein blood than in peripheral blood. Other patients have shown similar values.

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* The plasma 17-ketosteroid[42] and estrogen[43] determinations were performed under contract by the Bio-Science Laboratories, Los Angeles, Calif.

The influence of androgens upon various aspects of convalescence is being investigated in our laboratory and in various other clinics.

Plasma estrogen levels. FIGURE 7 shows total estrogen values obtained from peripheral blood preoperatively, during operation, and postoperatively.[44] The concentrations in adrenal vein blood and in ovarian vein blood taken during operation are also shown. In peripheral vein blood the level was approximately 3 gamma per cent before operation; following operation it was somewhat less.

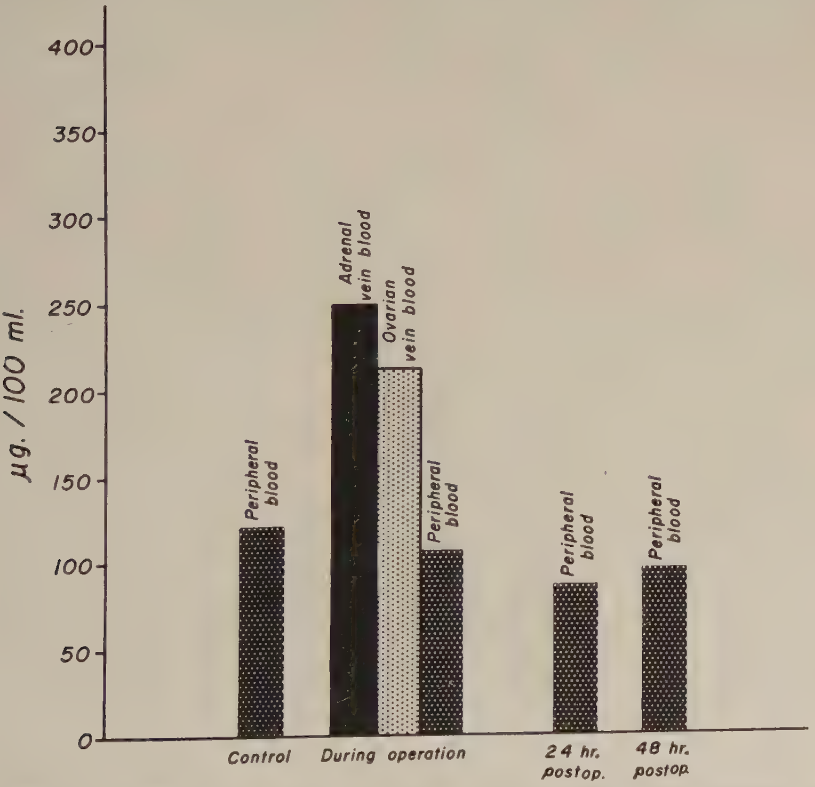

FIGURE 6. Plasma 17-ketosteroid levels before, during, and after gastric resection in a 32-year-old female patient, I.D. The 17-ketosteroid levels in peripheral plasma were not affected by surgery. The levels in the adrenal vein and the ovarian vein considerably exceeded peripheral values.

The peripheral level during operation was somewhat higher. However, in general an operation did not significantly affect the peripheral blood level of estrogens. The estrogen level in adrenal vein blood was usually substantially higher than that in peripheral vein blood. Moreover, the average value in the ovarian vein blood of women below the age of 40 (3 cases) was even higher than that in adrenal vein blood (9 gamma per cent as compared with 8 gamma). In contrast, in 4 women above the age of 40 the average total estrogen level in ovarian vein blood, which averaged approximately 3 gamma per cent, was no higher than that of peripheral plasma.

We have not yet studied enough women in the reproductive age group to make conclusive statements regarding the relative concentrations of estrogens in adrenal as compared with ovarian vein blood. Nevertheless, the data at this time point up the fact that the adrenals do contribute significant amounts of estrogen in both females and males.

Estrogens also have been implicated in modifying the qualitative aspects of convalescence. It has been suggested, for example, that one of the reasons women may show less metabolic response than men to a given operation, even when corrections are made for differences in lean body mass, is the increased total estrogen secretion provided by the ovaries. Certainly we can

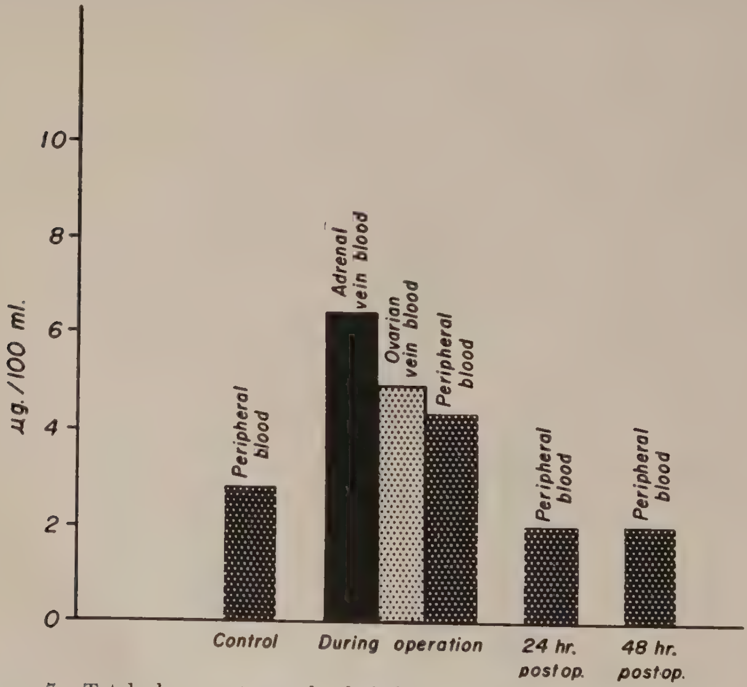

FIGURE 7. Total plasma estrogen levels before, during, and after gastric resection in patient I.D. Total estrogen levels in peripheral plasma were not significantly altered by surgery in most patients so studied. Estrogen levels in adrenal vein plasma usually exceeded those in peripheral blood, as did the levels in the ovarian vein plasma of young women.

Table 3

Cholecystectomy: Ether-Cyclopropane
Epinephrine and Norepinephrine Levels in Adrenal and Peripheral Venous Plasma (gamma/l.)

Preoperative		
Peripheral vein	E	1.0
	N	4.0
During operation		
Peripheral vein	E	2.1
	N	3.0
Adrenal vein	E	12.5
	N	57.6
Postoperative (4 hours)		
Peripheral vein	E	1.0
	N	4.1

all think of many examples in which female physiology is altered, in contrast with that of males, by virtue of the fact that women secrete more estrogen.

To summarize the information concerning plasma 17-ketosteroids and estrogens, it may be stated that the levels in adrenal vein blood sharply exceed those of peripheral blood. Both the ovary and the adrenal are capable of secreting significant amounts of both androgens and estrogens, with their known and unknown effects upon various facets of convalescence.

The catechol amines—epinephrine and norepinephrine.[45] Utilizing the method of Weil-Malherbe and Bone,[46] we have studied the effect of major surgery on the plasma levels of epinephrine and norepinephrine in peripheral blood, and have also measured the concentration of these hormones in adrenal vein blood obtained at surgery. Representative data from a single patient are shown in table 3. The epinephrine level in peripheral blood rose following surgery, but the norepinephrine level did not. These findings are similar to those in 4 other patients so studied.

There can be little doubt that many of the vascular alterations associated with major operations or accidental trauma are the result of increased adrenal medullary activity.

Correlation of Adrenal Activity with Certain Other Aspects of Metabolism

It has been shown that almost all of the usual activities of the adrenal cortex are altered following major surgery. Nevertheless, it is not enough merely to demonstrate an increase in the activity of an organ such as the adrenal; it is important also to attempt to draw correlations and, if possible, cause and effect relationships between the observed increase and other changes commonly observed in convalescence. Therefore, the data in figure 8 are presented to indicate that other important aspects of early postoperative metabolism can be correlated with the observed increase in various segments of adrenocortical activity, although these aspects need not be the *result* of an increased adrenocortical activity.[48, 49] It may be seen that, while patient W. C. was in a slightly positive nitrogen balance for several days preceding surgery, he went into a negative nitrogen balance following surgery. On the sixth postoperative day the nitrogen balance again became positive. Along with the loss of tissue protein as nitrogen, there was an increased urinary excretion of potassium and doubtless a combustion of body fat. In other words, these atomic and molecular alterations, caused by hormonal and nonhormonal stimuli, initiate—that is, they produce—*changes in body composition.*[50]

Changes in Body Composition

As already noted, following a really major operation, many changes occur in the relative and total body concentrations of nitrogen as protein, of carbon as fat, and of water and electrolytes. In health, the person of average obesity may have the following body composition: fat 18 per cent of body weight, fat-free solids (organic and inorganic) 22 per cent, and total body water 60 per cent (FIGURE 9). However, as originally proposed by Behnke[52] and later confirmed by other investigators,[53-56] fat constitutes the major variable in the healthy adult. Furthermore, body fat and total body water, including the body fluid compartments,[57] bear an inverse relationship to each other (FIGURE 10). That is, the greater the percentage of body weight represented by fat, the less the percentage represented by water. The extremely obese

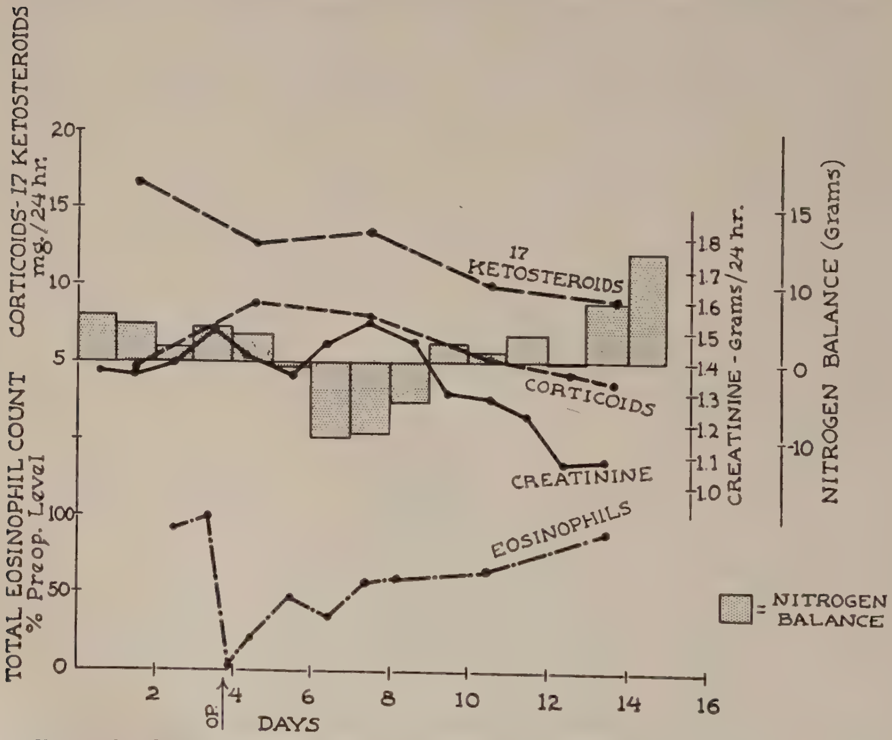

FIGURE 8. Gastric resection effect of operation on nitrogen balance, total eosinophil counts, and urinary excretion of creatinine, corticoids, and 17-ketosteroids in patient W.C. The increase in adrenocortical activity is correlated with nitrogen metabolism. The negative nitrogen balance, which began on the second postoperative day, reflected lean tissue loss, a change in body composition through catabolism. The sharply positive nitrogen balance, which began on the tenth postoperative day, reflected lean tissue gain, a change in body composition through anabolism. Reproduced by permission from Hardy *et al.*[47]

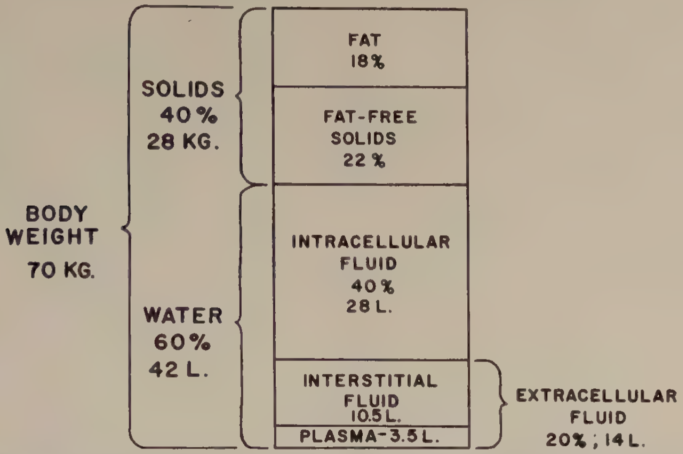

FIGURE 9. Body composition of a normal male of average obesity. In health, fat is the major variable in the body composition of the adult. Reproduced by permission from Hardy.[51]

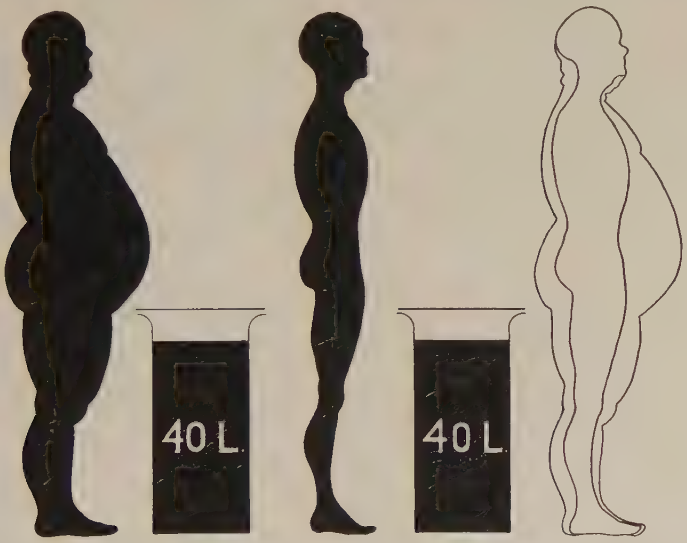

FIGURE 10. Body water versus body fat. In individuals of approximately equal height, bony structure, and musculature, but of widely different degrees of obesity, the volumes of total body water may be almost equal. Reproduced by permission from Hardy.[51]

but otherwise healthy subject may contain only 42 per cent water, while the very lean subject may contain 73 per cent water (TABLE 4).[51]

The body constituents are in constant turnover.[59]

Methods for Measuring Changes in Body Composition

Aside from balance studies, one can use the dilution method to follow changes in total body water,[60] body fat, and lean body mass, as well as changes in

TABLE 4

TOTAL BODY WATER (D_2O DILUTION SPACE) AND BODY SIZE RELATIONSHIP*

Subject	Mass, W	Stem length, L	Nutritive index, N_0†	$N_0 - N_m$‡	Percentage overnutrition above minimum value, $\left[\left(\frac{N_0 - N_m}{N_m}\right) \times 100\right]$	Total body water		
						Amount	Percentage of body weight	Percentage deviation from maximum value
	Kg.	*Cm.*			*Per cent*	*L.*	*Per cent*	*Per cent*
Leanest (theory)	(56.4)	(91.0)	(0.42)‡	(0.00)	(0.0)		(75)	(0.0)
J.M. ♂	60.9	91.0	0.43	0.01	*2.4*	44.5	73	*2.4*
H.G.B. ♂	60.0	81.3	0.48	0.06	*14.3*	41.1	69	*8.0*
J.D.H. ♂	77.3	83.8	0.51	0.09	*21.4*	46.6	61	*18.7*
J.R. ♂	66.4	76.0	0.53	0.11	*26.2*	37.6	57	*24.0*
W.B. ♂	121.0	90.2	0.55	0.13	*31.0*	60.6	50	*33.4*
S.G. ♂	116.0	81.5	0.60	0.18	*42.9*	48.3	42	*44.0*
M.McG. ♀	53.7	90.2	0.42	0.00	*0.0*	36.4	68	*9.3*
A.D. ♀	59.1	82.6	0.47	0.05	*11.9*	35.3	60	*20.0*
J.R. ♀	54.6	75.0	0.51	0.09	*21.4*	31.7	58	*22.7*
W.T. ♀	86.4	76.2	0.58	0.16	*38.1*	45.1	52	*30.6*
Fattest (theory)	(111.0)	(76.2)	(0.63)	(0.21)	(50.0)		(40)	(46.7)

* These data document the proposition that, in health, body water and body fat bear an inverse relationship to each other. If one is known, the other can be estimated. The subjects presented were carefully selected to cover a wide range in degrees of obesity. The leanest male contained 73 per cent water and exceeded the theoretical minimum normal body fat by only 2.4 per cent. In contrast, the most obese male contained only 42 per cent water and exceeded the theoretical minimum normal body fat by 42.9 per cent.[51]

† N_0 = *observed nutritive index* = $W^{1/3}_{\text{gm.}}/L$ cm.[58]

‡ N_m = *minimum nutritive index*, or minimum value of $N_0 = 0.42$.

sodium and potassium pools. Unfortunately, since methodology is not as precise as one might wish it to be, the error involved in such dilutional measurements is disturbingly large, and the measured changes in body composition must be fairly extensive to be considered valid.

Nevertheless, changes in body composition can be quite large and thus obviously significant.[61]

Factors Influencing Postoperative Weight Loss and Associated Compositional Change

It is a familiar fact that, following a major operation, the patient may gain some weight for a day or two if he retains more administered fluid than he loses; however, a more characteristic feature of early convalescence is weight loss. This tissue loss is influenced by preoperative nutritional status, the nature of the operation and of the infection, and the patient's sex; by the qualitative and quantitative aspects of postoperative alimentation; and by excessive losses, as from a large open wound, as well as other factors. Both lean tissue and fat are lost in the early postoperative period, the stage of catabolism. After a week or more, a positive nitrogen and potassium balance reflects a repletion of lean tissue; even later in convalescence, fat is regained.

Examples of Compositional Change

Water retention and water loss. There are many circumstances in surgery in which the immediate body weight and compositional change are due largely to changes in total body water content. Many patients gain a few pounds postoperatively because the interplay of antidiuretic hormone and aldosterone induces temporarily a partial renal retention of infused fluids. This is due to increased tubular reabsorption. However, the severely burned patient almost invariably gains considerable weight as water if he is adequately treated to prevent shock (FIGURE 11). Conversely, explosive vomiting or diarrhea can rapidly reduce body weight and body water content without initially altering the content of body fat and organic solids.

Lean tissue and fat loss. Most patients lose both lean tissue and fat following major surgery or extensive trauma (FIGURE 12). Lean tissue loss is reflected in negative nitrogen and potassium balances. Fat loss, if sufficiently great, can be detected by total body water measurements and by estimates of the carbon balance, as demonstrated by Moore. Following cholecystectomy the patient may lose ten pounds. During convalescence, first the lean tissue loss and next the fat loss are regained, although these repletions may take months. Curiously, patients tend to associate the late weight gain with the return of strength and the feeling of well-being. One feels that this common observation of the laity may have more physiological importance than is usually accorded it. Certainly the improved general health that comes with the resti-

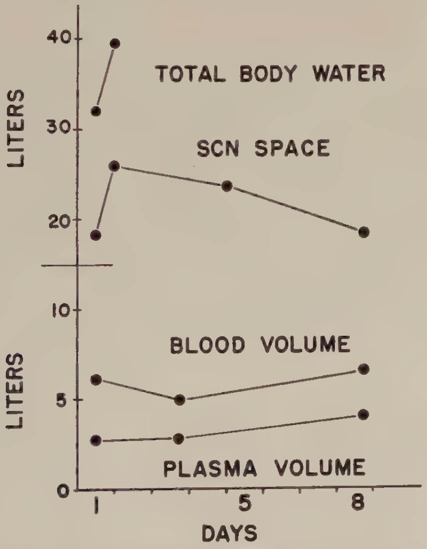

FIGURE 11. Fluid volumes in a 65-year-old female patient, M.C., who suffered a 40 per cent flame burn. The patient gained almost 7 kilograms during early fluid therapy. The water gain was found to be situated largely in the extracellular space. By the end of the eighth postburn day, however, the weight curve had returned to the admission level, and thereafter it declined steadily. Reproduced by permission from Hardy [3]

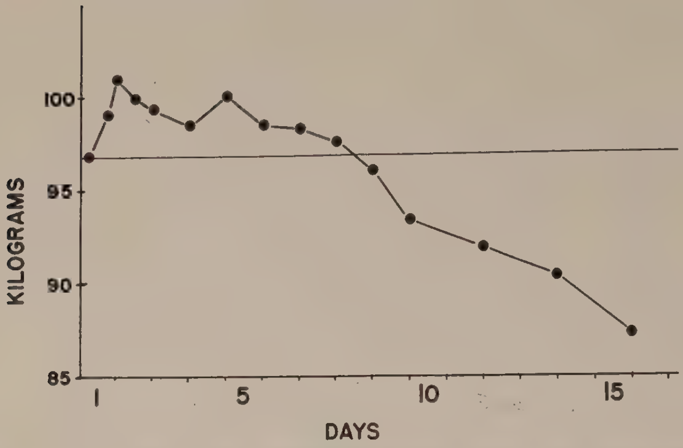

Figure 12. Body weight in the 65-year-old female patient, M.C., who suffered a 40 per cent flame burn (figure 11). The inexorable decline in the body weight curve following the initial rise—from fluid retention—was due to whole tissue loss. A markedly negative nitrogen balance reflected lean tissue loss, and the rapid mobilization of subcutaneous fat was apparent from physical examination. Efforts at nutritional therapy were only partially effective. The severe infection with fever, plus abnormal losses from the open burn wounds, increased caloric and protein requirements far beyond the alimentation that could be achieved in this critically ill patient. Reproduced by permission from Hardy.[3]

tution of normal amounts of body fat following operation is not entirely psychological.

Fat gain and lean tissue loss. Such a circumstance is encountered in Cushing's syndrome,[62] whether naturally occurring or iatrogenically induced, in which muscle wasting is reflected in negative nitrogen and potassium balances, and fat gain results in truncal obesity (the weak fat man).

Another situation in which one can observe a regression of muscle mass concomitant with an increase in body fat is during the cortisone treatment of girls with the adrenogenital syndrome. If the girl is at the age of puberty, the suppression of ACTH release, reducing adrenal androgen production, may allow her own ovarian estrogens to produce rapid feminization, with the development of the usual fatty contours. We treated such a girl, and fat was deposited in the thighs and buttocks so rapidly that white skin striae developed. Meanwhile, the muscle excess that had been produced by the adrenal androgens regressed.

Lean tissue and fat gain. As pointed out above, this is characteristic of convalescence and of normal growth.

Significance of Compositional Changes

These several examples indicate some of the far-reaching changes that can occur in body fat, fat-free solids, lean tissue mass, water, and electrolytes in the postoperative period. There is no question that the rate and the degree of loss of these substances, as well as the rate of their subsequent restitution, bear an intimate relationship to the rate and quality of convalescence and to the readiness of the individual to return to work. It would be premature to imply that we now know what factors regulate the degree to which depletions of various types will occur, or what factors regulate the rates and extent to which they will be repaired in a reasonable length of time. Nevertheless, we already do know numerous factors that cause the dissolution of various tissues and the excretion of various substances. We also know many factors that definitely contribute to a well-ordered convalescence. One of these is a good appetite, and this brings to mind the relationship that exists between the postoperative return of appetite and the degree of weight loss observed. Since it is generally agreed that the appetite is controlled in considerable measure by centers in, or adjacent to, the hypothalamus, we conclude this presentation with re-emphasis on the integrative function of the nervous system in convalescence.

Summary

(1) The metabolic response to surgery involves all organs of the body. Ways in which the activity of various organs is altered postoperatively have been outlined. As in normal physiological activities, the nervous, the cardiovascular, and the endocrine systems act as the principal coordinators of convalescence.

(2) The injury itself serves as the initiating mechanism that releases the postoperative metabolic reaction. The feedback mechanisms that, in time, reverse the metabolic response to surgery are largely unknown.

(3) Adrenal activity has been studied by the following means: (a) urinary excretion of corticoids, 17-ketosteroids, and aldosterone; (b) total eosinophil counts; and (c) measurement of the plasma levels of 17-21-hydroxycorticosteroids, 17-ketosteroids, estrogens, epinephrine, and norepinephrine in peripheral venous blood and adrenal venous blood.

(4) Ovarian venous blood levels of 17-ketosteroids and estrogens in young women sharply exceeded those in peripheral plasma.

(5) Changes in body composition occur following major operations. A brief increase in body weight due to water retention is usually followed by a decrease in weight due to loss of both lean tissue and fat. The lean tissue loss is reflected in negative nitrogen and potassium balances. Fat combustion may be demonstrated by measuring the respiratory quotient of expired air. The normal inverse relationship between body water and body fat that is useful in the healthy subject is less reliable in the acutely sick patient, who may have abnormal fluid collections.

(6) The eventual restitution of amounts of lean tissue and fat that are normal for the individual in question is related to appetite and promotes the sense of well-being. Complete convalescence may well not obtain until full nutritional recovery has been realized.

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REPAIR OF TISSUE AFTER INJURY*

By J. Englebert Dunphy
Department of Surgery, Harvard Medical School, Cambridge, Mass., and Fifth Surgical Service and Sears Surgical Laboratory, Boston City Hospital, Boston, Mass.

A number of years ago Alfred Blalock, Johns Hopkins University, Baltimore, Md., pointed out that the increase in our knowledge of the nature of shock was making the word itself obsolete; that a "unified concept" of shock could not be reconciled with the observed facts, and that it was necessary to specify what kind of "shock" was under discussion. Similarly, one may speak properly of wound healing in general terms, but if one is referring to patterns, mechanisms, sequences, or any observed phenomena having a bearing on the nature of repair, it is essential to be considerably more precise. For example, the healing of epithelium does not conform to the same pattern as the production of granulation tissue. Contraction of the wound must be distinguished from cicatrization and scar formation. Fibroplasia is not necessarily synonymous with a gain in tensile strength. Although there is a delay in the gain in tensile strength in a sutured wound, this period is not one of mere exudation, absorption, and demolition and should not be regarded as a lag phase.

The Nature of Repair

Biologists and experimental zoologists regard regeneration and repair as having two forms: epimorphosis, which is the direct replacement of lost tissue by the formation of new tissue, and morphallaxis,[1] in which the remaining portion of the body is remodeled to restore the lost part. Until recently wound healing has been regarded as an essentially epimorphic process, particularly in vertebrates and higher mammals. More recent studies, however, indicate that various components of the process of repair in animals and man involve morphallaxis on a small scale.

The reaction of tissue to injury varies with the type and extent of injury and with the tissue injured. Regardless of the type of injury, however, the reaction to it may be studied in any of several component parts of the repair process. These are closely related and in varying degrees interdependent, but they may be recognized and studied separately as epithelization, contraction, vascularization, connective tissue repair, and the repair of special tissues such as bone, muscle, tendon, or nerve. Each of these components merits a brief discussion.

Epithelization

Epithelization, the restoration of the surface of an open wound, is accomplished largely by migration and hence belongs in the category of morphallaxis. Although mitosis can be observed during the process of epithelial repair, it plays a comparatively small role in the restoration of a new surface covering. Of particular interest to the surgeon are the studies of Hartwell[2] and of Gill-

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man and Penn[3] on sutured wounds. Hartwell's observations on human wounds were made about thirty years ago, but their importance and significance have been overlooked. More recently Gillman has made similar observations, both in experimental wounds in animals and in man. In brief, in a surgically closed wound epithelium does not unite at the surface by growing across a fibrin clot or a mound of granulation tissue, but plunges rapidly by a process of migration into the depths of the wound along the cut edge until it comes in contact with dermal connective tissue. Here it thickens somewhat irregularly and forms a union with a similar downgrowth from the other side of the wound. This occurs under the fibrin clot that initially sealed the surface of the wound. Epithelial closure occurs before any new collagen has been formed in the wound and before the development of well-established granulation tissue. The prickle cell layer of normal epithelium is the principal source of the migrating new epithelium. The sequences described by Hartwell and Gillman are depicted diagrammatically in FIGURE 1.

After the formation of new connective tissue beneath the dermis, the new epithelial union is realigned and pushed upward to form a more normal surface lining. Purely from the point of view of time sequences, then, epithelial coverage is completed before connective tissue repair, but final restoration of a new epidermis follows changes in granulation tissue in the depths of the wound. Since it is not known whether these time sequences have any causal relationship, this is a fertile area for study. Gillman suggests that this sequence may be disturbed in carcinogenesis.

From the practical point of view the same downgrowth of epithelium can be observed around sutures and, if sutures are large and remain in place for any length of time, this growth becomes so formalized that a permanent mark remains on the surface of the skin.

A number of biochemical changes have been noted in migrating and healing epithelial cells.[4-6] Although they are not discussed in this paper, their relationship to biochemical changes within granulation tissue may ultimately prove to be of great importance and interest.

Vascularization

Little is known about the forces that initiate growth of new blood vessels in the wound. Allgower[7] has suggested that these may form in part from wandering mononuclear cells that de-differentiate. On the other hand, Algire[8] feels that new blood vessels do not appear without evidence of growth from old. My own observations confirm the latter view. The growth of new blood vessels into the interstices of a plastic sponge can usually be traced to capillary networks and arterioles surrounding the sponge. This process appears also to be largely one of morphallaxis. Endothelial-lined tubes can be seen extending into the interstices of the sponge without evidence of mitosis. Williams[9] has shown that vascularization of grafts may be determined by this metabolic activity. The type of tissue grafted also exerts a demonstrable influence on its vascularization. Conversely, E. R. and E. L. Clark have shown that capillary proliferation may have an adverse effect on the growth of epidermal tissue.[10]

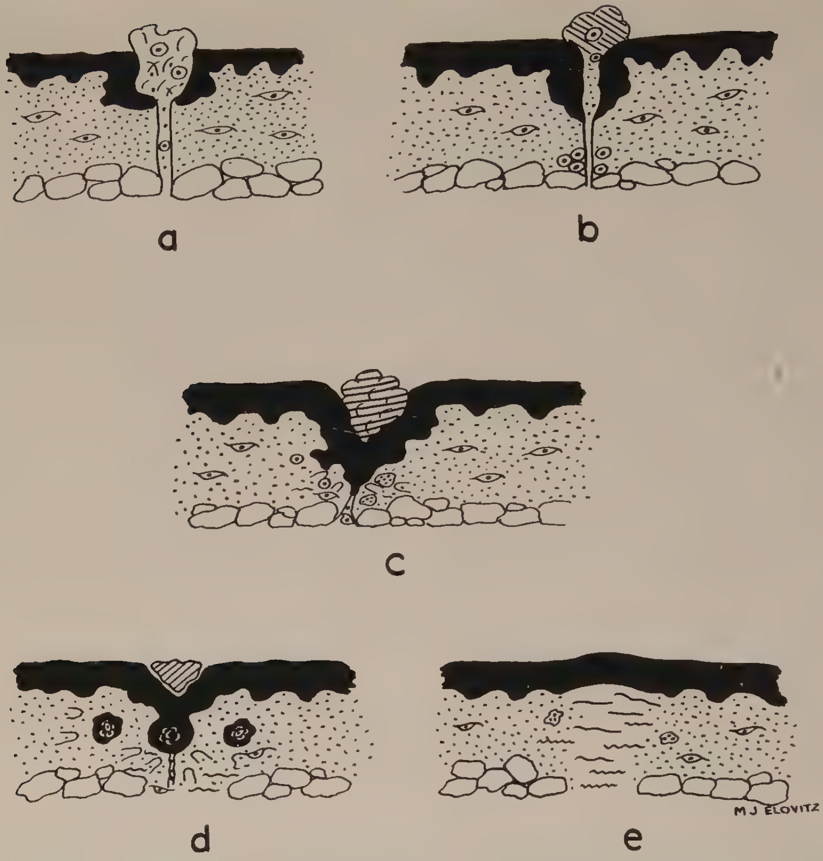

Figure 1. Diagram of the anatomical sequences of epithelization showing (a) the manner in which the epithelium spreads by migration into the wound, sealing it before new connective tissue is formed; (b) that the epithelial union occurs in the depths of the wound despite careful suture of the edges—at 48 hours; (c) the wound between 5 and 8 days; (d) the wound between 10 and 15 days; (e) the wound after 25 days.

Thus, although it is clear that new tissues require new blood supply, the interrelation between the growth of new tissue and its vascularization is far more complex than has been appreciated and provides a fertile field for study.

Contraction

Contraction is a physiological process by which open soft-tissue wounds close. It is an example of morphallaxis, since the adjacent normal tissue is remodeled in order to close the defect in the soft tissue. Formerly the closing was thought to be due to the contraction of collagen fibers in the granulation tissue within the center of the wound. Several recent observations make it clear that this is not the case. Van Den Brenk[11] has shown that contraction of a wound may be stopped by a dose of irradiation that will not interfere with the formation of granulation tissue and scar. Contraction has been noted in the scorbutic wound, in which little or no collagen is formed. Recent careful biometric and biochemical studies by Grillo *et al.*[12] and Watts *et al.*[13] at the Massachusetts General Hospital, Boston, clearly indicate that contraction is independent of the formation of collagen, the absorption of fluid, or the growth of granulation tissue within the center of an open wound. The forces for contraction appear to lie at the periphery of the wound, perhaps in changes within existing collagen fibers.

Of practical importance to the surgeon is the fact that certain large soft-tissue wounds will close by contraction, as shown in FIGURE 2. Placing a full-thickness skin graft on such a wound will inhibit contraction. A classic example is the excised carbuncle on the back of the neck which, if covered by a thick-split or a full-thickness graft, evinces a permanent visible defect on which hair will not grow. If the wound is allowed to contract, however, the ultimate scar is so small that it usually cannot be seen.

Contraction is inhibited in burns and by necrotic tissue in the wound. It is well marked only where there are large soft-tissue defects, as on the back of the neck, the back, buttocks, and abdomen. In man, at least, contraction is limited over the anterior chest wall and on the arms and legs, particularly the palms and dorsum of the hands and feet. The reasons for these variations in the effectiveness of contraction are not known and from a practical clinical point of view they merit study.

Contraction must be distinguished from cicatrization and scar tissue. The term contracture has been applied to contraction by some authorities but, since contracture implies immobility, as in the contracture of a joint, it might preferably be restricted to the late effects of scar tissue formation. Cicatrization is the final stage of scar tissue formation—the final result of connective tissue repair.

Connective Tissue Repair

Regardless of the tissue involved, the tensile strength of united surfaces depends principally on connective tissue repair. Although there is a considerable delay in various wounds before new collagen appears and before there is a significant gain in tensile strength, this period is one of intense biological and biochemical activity and should not be construed as a lag phase concerned only with demolition and absorption. The interaction of cells, intercellular material, and fibers and the biochemical sequences involved in the formation of new collagen are so complex as to defy analysis. A number of important observations have been made in recent years; the summary of work from this laboratory and from other groups follows.

Connective tissue repair appears to be a truly epimorphic process in the sense that cells proliferate and multiply and new tissue is produced by biochemical synthesis. The source of the cells involved in connective tissue repair is still a matter of debate. Allgower[7] produces evidence that wandering mononuclear cells and macrophages are involved. There is a considerable body of evidence against this view, however, and studies of connective tissue repair using a plastic-implanted sponge clearly indicate that under these conditions new connective tissue is produced from the periphery. This does not exclude

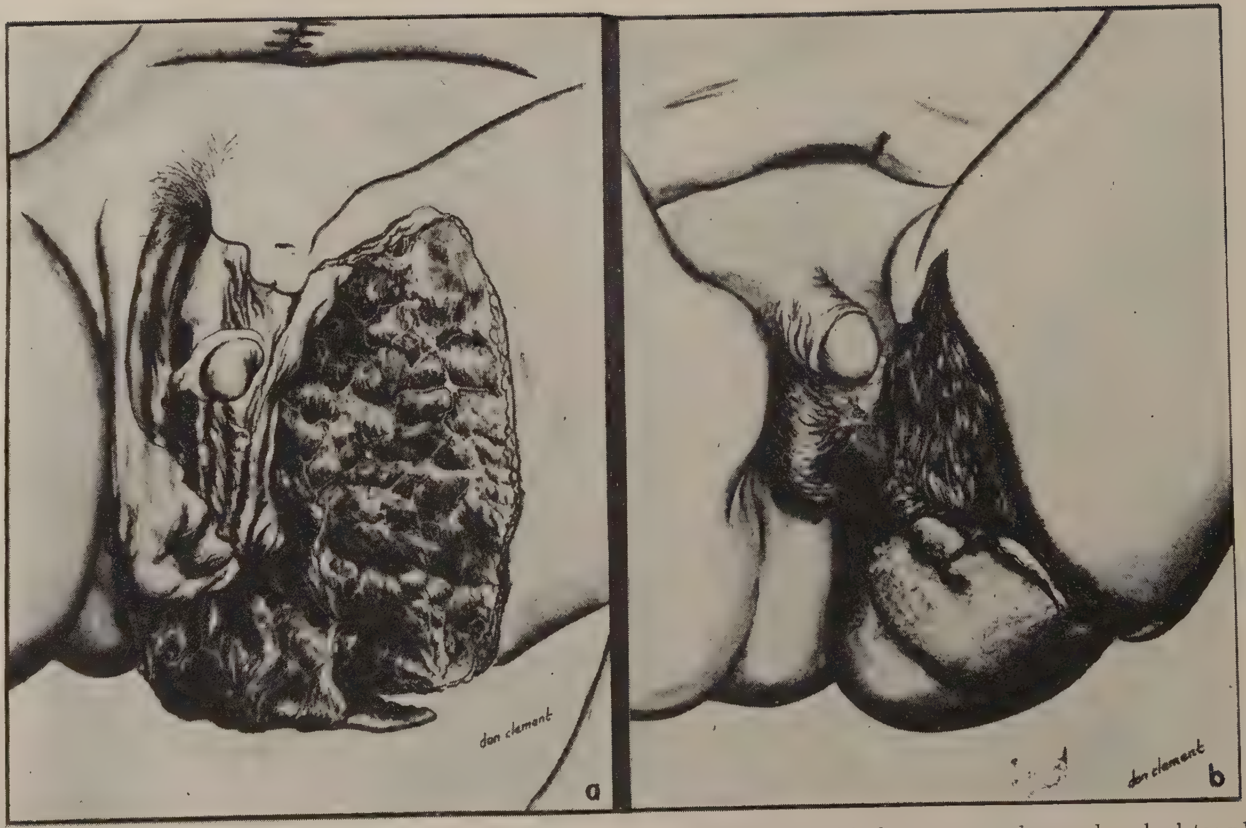

Figure 2. Example of wound contraction: (a) a huge shell wound of the buttock, and (b) the same wound several weeks later when the closure has been brought about by contraction.

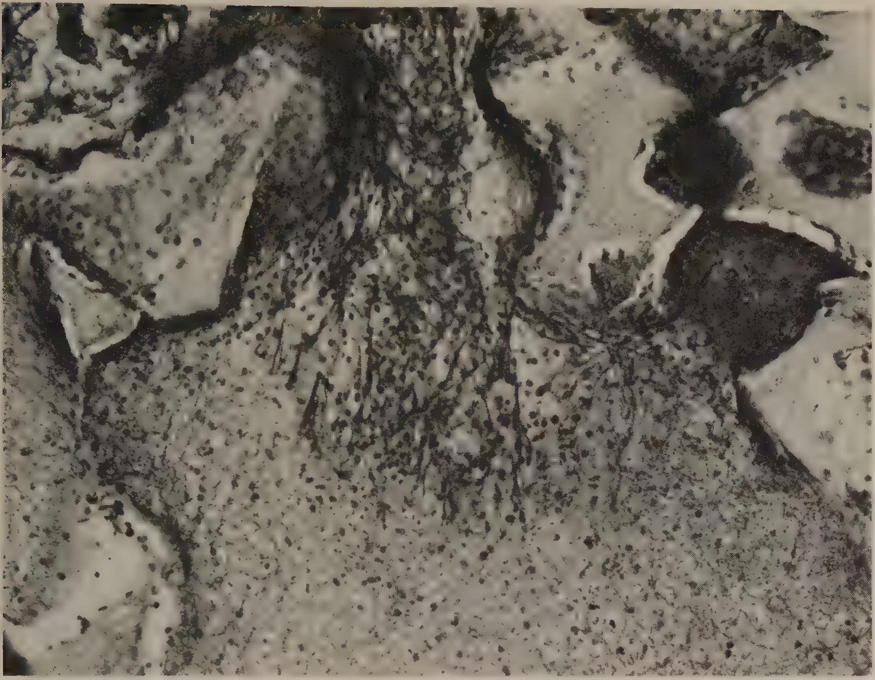

FIGURE 3. The organization of connective tissue in a plastic implant. Note that it appears to be from the periphery, although the sponge is uniformly filled with exudate within a few hours of wounding. Reproduced by permission from Edwards *et al.*[14]

the participation of wandering cells; but, if they do participate, they do not enter an implant within the first forty-eight hours in the initial exudation and, subsequently, de-differentiate to produce fibroblasts and organize the sponge uniformly. FIGURE 3 shows the appearance of a sponge biopsy at two days. The tendency toward peripheral organization is clearly seen.

It is my impression that the fibroblast participating in repair originates from loose areolar connective tissue, and not from the mast cells or wandering mononuclear cells. This is in accord with Gillman's view.[3] Hartwell[2] noted the tendency for connective cells seemingly to come from fatty layers of tissue, but thought that they represented macrophages that de-differentiated within areolar tissue. The exact origin of the connective tissue cell that participates in repair requires further study, although there is good reason to believe that it comes from preexistent loose areolar connective tissue.

Where muscle, fascia, and overlying subcutaneous tissue are widely dissected or undermined, as in muscle-retracting incisions, it appears likely that the fascia is being separated from its major source of new connective tissue. In this sense fascia is like tendon, for it does not unite by proliferation of fascial connective tissue cells, but by the participation of new connective tissue cells in adjacent areolar or fatty tissue. The adverse effects of obesity on wound healing are well recognized clinically. It may be that, when the loose connective tissue cells of areolar tissue are heavily laden with fat, their participation in the process of repair is retarded. This presents another area for study.

Examination of connective tissue by chemical and histochemical techniques clearly shows intense activity during the first six days after wounding. The nature of these changes and their ultimate role in repair have not been completely defined. Materials having high molecular weight and containing hexosamine enter the wound early after injury. The concentration of these materials in the wound falls progressively during the course of the first two weeks. Histochemical stains, such as Hale's colloidal iron stain and the periodic acid-schiff and metachromatic stains, are positive during the first few days after wounding and become negative in the later phases of repair. These observations have been interpreted as indicating an accumulation of mucopolysaccharides in the wound. It has been shown[14] by the sponge biopsy technique that the high concentrations of hexosamine materials are reached as early as six hours after implantation, when there is neither new connective tissue nor fibroblasts in the sponge.[14] This points strongly toward the plasma glycoproteins as the major source of the hexosamine. Grillo, Gross, and their associates have also furnished data suggesting that the height of concentration of hexosamine is reached immediately after wounding and falls progressively throughout the period of repair.[12, 13]

Current studies in our laboratory by D. S. Jackson indicate that in a sponge biopsy on the eighth day less than 5 to 10 per cent of the hexosamine material is associated with chondroitin sulfate or hyaluronic acid. This does not necessarily imply that the hexosamines in wounds are not of fundamental importance in repair. In these preliminary studies much more hexosamine appears to be incorporated with mucoproteins than with polysaccharides. Further study

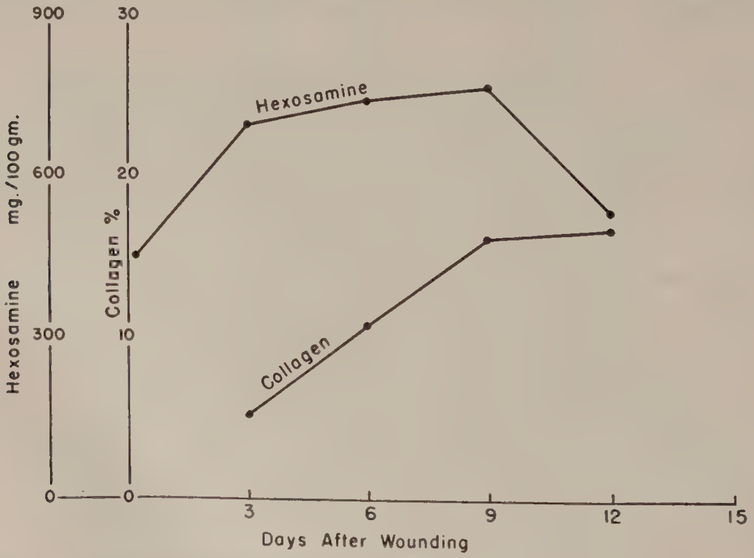

FIGURE 4. Chemical changes in connective tissue in repair in protein starvation. Reproduced by permission from Udupa *et al.*[15]

is needed to elucidate the significance of hexosamines, mucoproteins, and mucopolysaccharides in connective tissue repair. It is quite possible that fundamental differences may be detected between open and closed wounds. Clearly, differences can be detected under conditions of abnormal repair.

One of the most useful chemical measurements of connective tissue repair is the extraction from tissue of the amino acid hydroxyproline. This substance exists in significant quantity only in collagen and therefore has been accepted as a reliable index of the production of collagen in a wound. All observers are agreed that there is little or no hydroxyproline present early in the post-wounding period. This material can be found in the wound between the fourth and sixth days, and its concentration rises rapidly from the sixth to the twelfth day, after which it declines slightly. The reciprocal relationships of hexosamine-containing materials and collagen in the wound is of interest because it appears to be altered in abnormal types of repair. Apparently defective healing in scurvy differs fundamentally from that in protein starvation. Representative curves from earlier studies are shown in FIGURES 4 and 5.

Protein starvation seems to cause a delay in repair. The concentration of hexosamine rises somewhat more slowly and declines later, whereas the appearance and the production of collagen are delayed. These observations were made on open biopsy wounds and, in the light of our present interpretation of the significance of hexosamine, they require reappraisal by the sponge biopsy technique. Such studies are now in progress.

In scurvy, on the other hand, essentially no collagen is produced, although there is a progressive rise in the concentration of hexosamine. Here, again, the hexosamine data were derived from open wound biopsies and it is possible

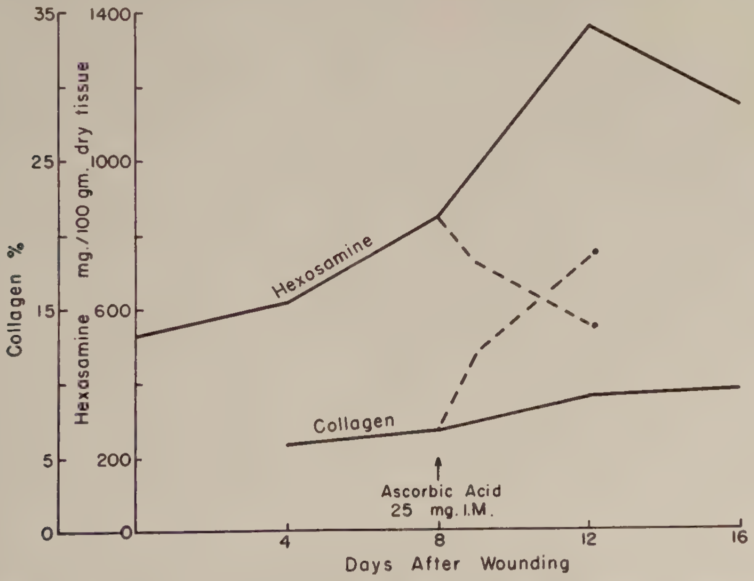

FIGURE 5. Chemical changes in connective tissue in repair in scurvy. Reproduced by permission from Dunphy *et al.*[16]

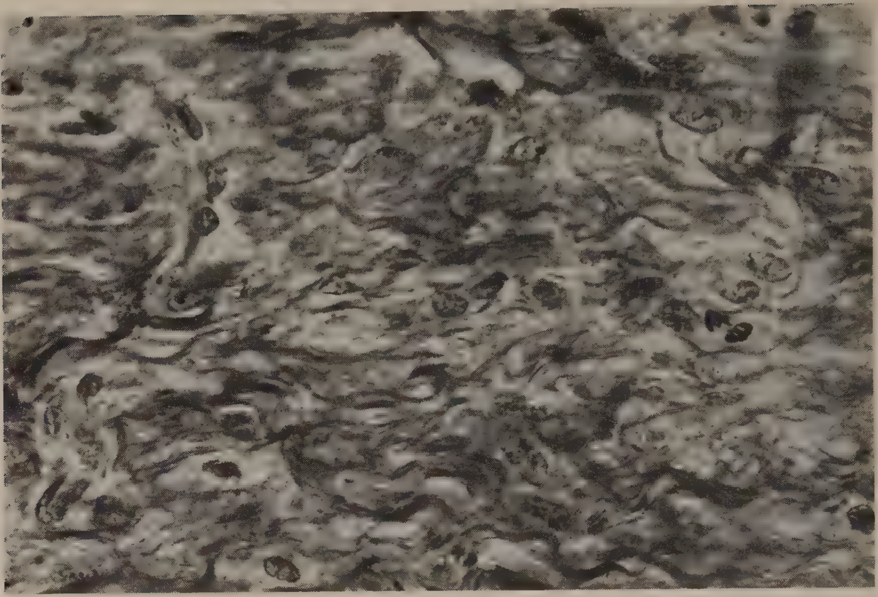

FIGURE 6. Concentration of mucopolysaccharides in a normal wound 12 days after injury. Note the light-staining intercellular material. Hale's stain. ×480. Reproduced by permission from Dunphy *et al.*[16]

that the more fragile, easily traumatized open wound contains more serum glycoproteins than does the normal wound. There is good correlation, however, between the data obtained by quantitative estimation of hexosamine and that obtained from histochemical studies of the protein-starved and scorbutic wound. In protein starvation, not only is poor collagen produced by ordinary staining techniques, but the concentration of mucopolysaccharides as estimated by Hale's stain, for example, appears to be less. By contrast, in scurvy there is an abundance of mucopolysaccharide-like material, as shown by Hale's technique. Representative examples are shown in FIGURES 6 and 7. This may mean, however, that the material is in an altered form and bound in such a way as to prevent it from reacting with the stain, rather than that there is an actual deficiency or excess of such material.

One of the most interesting chemical changes in the healing wound relates to sulfur metabolism. Williamson[17] has shown that in protein starvation there is a relative retention of sulfur following wounding and a progressive increase in the concentration of sulfur in granulation tissue, which corresponds very closely to the curve of gain in tensile strength and in the production of collagen. Curiously, however, there is very little sulfur in collagen.

The role of sulfur in repair has been studied by means of S^{35}-labeled sodium sulfate and methionine. Space does not permit a detailed discussion of the subject, but apparently when sulfur is given as methionine it is distributed widely throughout the wound whereas, when given as sodium sulfate, it appears largely in the ground substance. There is a diminished uptake of sulfur

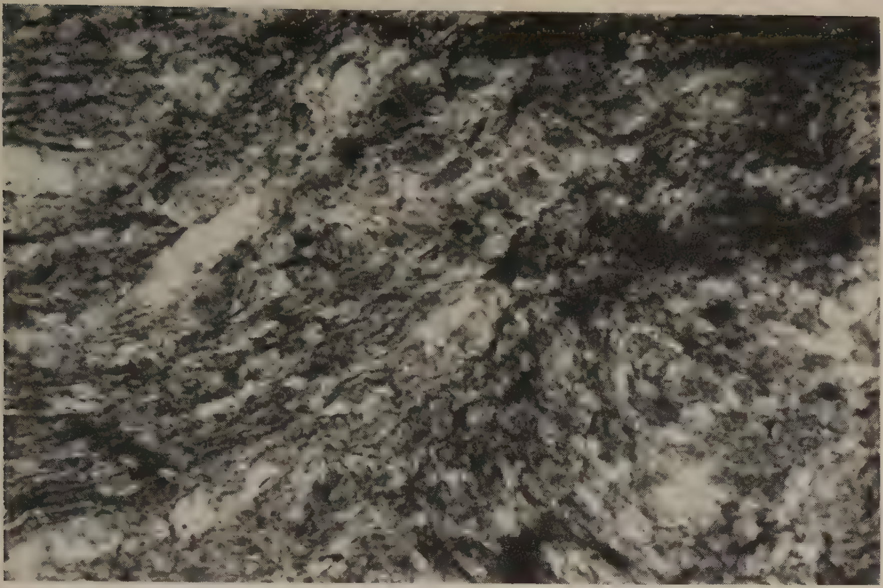

FIGURE 7. The concentration of mucopolysaccharides in a scorbutic wound 12 days after injury. Note the deep staining of intercellular material. Hale's stain. ×480. Reproduced by permission from Dunphy *et al.*[16]

in various states of abnormal repair, particularly in scurvy and after the administration of cortisone.

The impairment of repair processes by ascorbic acid deprivation or by the administration of cortisone is manifested in the synthesis of connective tissue at a time when other components of wound healing are either not affected or affected in a different manner. For example, the studies of Abercrombie *et al.*[18] suggest that in ascorbic acid deprivation there is a deficient production of collagen, but the progress of contraction may be relatively unaffected. Epithelization of a wound continues when connective tissue repair has been strikingly impaired by protein starvation. Cortisone has been shown to stop contraction of a wound, but without completely suppressing collagen formation. Conversely, contraction may continue despite protein starvation. The meaning of these observations and the interrelations between the various components of repair and the totality of wound healing are fertile sources for further study.

One thing is certain: the biochemical consequences of repair extend far beyond the surgical wound itself. Indeed, the healing of any tissue, regardless of the stimulus, merits study by biochemical and histochemical techniques. For instance, the interrelationships of ground substance, granulation tissue, and epithelization may provide important clues to the nature of carcinogenesis. It is by no means unlikely that in carcinogenesis defective reactions of the stroma in ground substance may be fully as important as an increased or abnormal growth potential within the epithelial cell involved. Although biochemical and histochemical studies of connective tissue have provided a new perspective on the healing wound, practical applications must await future developments.

The Healing of Special Tissues

This survey of the repair of tissue after injury would not be complete without a comment on the healing of special tissues. Much work has been done in this field, but particular attention should be drawn to the contributions by Mason and Allen[19] and, more recently, by Peacock* on the healing of tendons, by Clark[20] and Jones[21] on the healing of striated muscle, and by Urist and McLean[22] on the healing of bone. The role of connective tissue repair in each of these processes is a prominent and important one, but it appears that in each instance, with the passage of time, a very slow regeneration of the specialized tissue takes place. The healing of special tissue is therefore a very gradual epimorphic process. In bone, as is well known, this proceeds to the point at which the "scar" can no longer be seen.

If the extent of the injury and the reaction to it are intense or continuous, so much new connective tissue may be formed that its replacement by special tissue cannot be accomplished. The causes of such connective tissue responses are many, including such variable factors as the nature of the initial stimulus, for instance, a burn versus a knife, the presence of foreign bodies, or systemic factors such as a nutritional defect.

Summary

The repair of tissue after injury may be brought about by the formation of new tissue, epimorphosis, or by the remodeling of old tissue, morphallaxis. The healing wound should be regarded as having certain closely related component parts, namely, epithelization, vascularization, contraction, connective tissue repair, and the repair of special tissue. Morphallaxis is a prominent feature of epithelization, vascularization, and contraction. Connective tissue repair is principally an epimorphic process. Biochemical and histochemical studies of connective tissue repair have provided a new perspective on the reparative processes, but practical application of this knowledge awaits further study.

The repair of special tissues varies with the extent of an injury and with the tissue involved. The initial union is accomplished by connective tissue that is slowly replaced by the special tissue concerned. An excessive or abnormal connective tissue response may prevent complete repair by a special tissue.

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A SURVEY OF SOME PHYSIOLOGICAL RESPONSES OF DOMESTIC ANIMALS DURING THE IMMEDIATE POSTSURGICAL PERIOD

By Mark W. Allam and John E. Martin
School of Veterinary Medicine, University of Pennsylvania, Philadephia, Pa.

The problem of surgical convalescence in domestic animals has not been studied carefully. In general, the veterinarian depends on past experience rather than on quantitative data to guide him in his decisions during the convalescent period. Although careful postsurgical observations are made on such factors as the animal's appetite, water consumption, and urine and fecal output, there has been little attempt to quantify these functions. Likewise, there is little information on the optimal time at which an animal may engage in various types of exercise or work following surgery. Studies planned to obtain such information should be of value not only to the veterinarian, but also to the physician. The early return of an animal to normal activity following surgery is important in our economy and, at times, it can be a factor in the emotional stability of the owner. The rapid return of a cow to full milk production puts more dollars in the farmer's pocket; the return of the pet dog to normal activity may contribute to the tranquility of a home.

From a broader viewpoint, a study of various functions in animals as they are related to recovery from surgery may contribute important information to the general understanding of convalescence in man. The most outstanding single difference between the surgical convalescence of man and animals is the absence of subjective symptoms in the latter, which means that the problem of measuring the rate and completeness of recovery in animals is purely an objective one. Obviously, the physician must always take into account the influence of psychological factors on recovery and, precisely because this is not the case in lower animals, studies of their recovery might contribute significantly to a clearer understanding of how psychological factors effect the rate of convalescence.

Comparison of Convalescence in Animals and Man

There are certain unique differences between the convalescence of animals and that of man. Some of these reflect inherent behavorial differences, while others are due to variations in management. Some of the important differences are:

Immediate postsurgical activity. Whereas for man there is ordinarily a variable period of complete or almost complete inactivity after major surgery, most animals exhibit spontaneous activity immediately following recovery from anesthesia. The dog in a cage or the horse in a stall will begin to walk about as soon as it can regain its feet. In fact, it is highly desirable for large animals such as the horse and the cow to stand again and move about as soon as possible. For instance, any prolonged recumbency for a cow can disrupt the functioning of the rumen and lead to bloating, which may have serious consequences. The effect of recumbency on various other functions in large animals has not been studied carefully, but general experience indicates that even relatively short periods are adverse. For example, horses and cows readily show oliguria during recumbency.

Pain threshold in animals. While it is difficult to make any direct comparison between the objective signs of pain in dogs and the subjective symptoms exhibited by man, most clinical evidence indicates that lower animals have a somewhat higher threshold for pain. It seems reasonable to expect that this fundamental difference contributes to variations in the surgical convalescent period of man and animal. Dogs that have undergone major abdominal surgery will usually move about freely within a few hours after the operation, whereas human beings, partly because of pain, are often reluctant to do so.

Functional status. It is often possible to place man in a relatively basal state before and immediately following surgery, particularly of the elective type. This is usually not possible with animals. The dairy cow may continue milk production at a relatively high level both before and after surgery. Following major surgery, it might be desirable to limit this "physiological stress," especially if milk production is carried on at great expense to the animal, as happens if anorexia is present. However, inhibition of milk production is not ordinarily possible or economically desirable, even though continued lactation may impede the animal's full recovery.

Regulation of diet and water consumption. As a result of their clinical experience, veterinarians make little attempt strictly to regulate diet and water intake by animals following surgery, except after a particular type such as enterotomy. The almost total lack of dietary restriction does not appear to have any harmful effect on the rate of an animal's recovery from surgery. Dogs are frequently placed on a full diet and allowed free access to water within twelve hours after total hysterectomy.

Psychological factors. Surgical convalescence in animals obviously is not influenced by many of the psychological factors that may be present in man. These include concern about economic factors and worry about the surgery itself, as well as the rate of recovery. For example, a dog undergoing surgery for carcinoma of the mammary gland is not subjected to the same stress as that of a woman undergoing the same operation. The effect that this considerably lower "psychological barrier" in animals has on their rate of recovery is difficult to assess, but it seems reasonable to suppose that the animal's convalescence is less impeded. For instance, cows undergoing a rumenotomy often continue to ruminate during the course of surgery, a function readily disturbed by severe pain and fear.

Rapidity of surgical convalescence. As already noted, most available evidence indicates that animals return to full activity far more rapidly after major surgery than does man. For example, following herniorrhaphy dogs return to full activity within two weeks. Some reports indicate that the human patient is not back "on the job" for as long as forty-two days.[1] Does this reflect a more rapid return to homeostasis in animals, or does it mean that because of certain practical considerations the animal is "forced" to return to full activity more rapidly? Does the fact that animals voluntarily begin to move about freely soon after surgery contribute to a more rapid return to normal physiological mechanisms? Answers to these important questions might contribute to more adequate management of the convalescent patient, whether animal or man.

Immediate Postsurgical Period in Animals

The immediate postsurgical period is influenced by the type of anesthetic employed. Although ether is often employed for dogs, some of the other general anesthetics used for domestic animals differ from those administered to man. For example, chloral hydrate, injected intravenously, is a common general anesthetic for horses, and pentobarbital sodium is used more often for dogs than any other type of anesthetic.

Regardless of the agent employed, animals attempt to stand as soon as they have recovered from anesthesia (FIGURE 1). The horse may struggle and attempt to rise several times before being successful. Many horses will begin to eat hay and walk about in the stall soon after standing. Defecation and urination are frequently observed during the first hour following recovery from anesthesia. Generally, horses will not drink water until approximately 6 hours after completion of surgery. During the first 24 hours after surgery, horses are allowed only hay, following which a normal diet, including grain, is supplied.

Dogs often will drink water as soon as they are able to stand. In fact, if

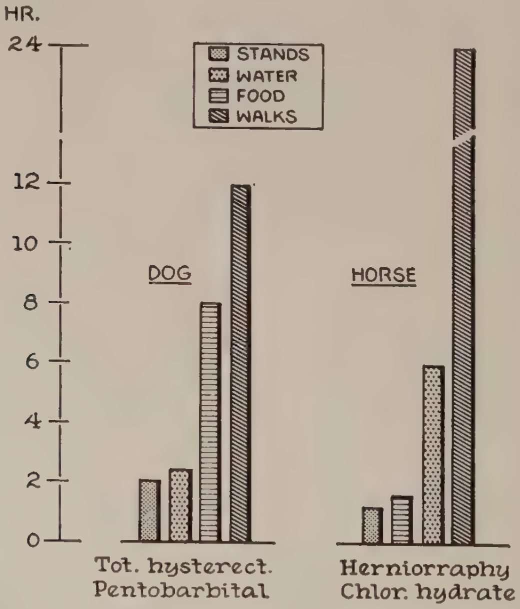

FIGURE 1. Typical postsurgical management of horses and dogs at the School of Veterinary Medicine, University of Pennsylvania. The interval shown is from the time the animal is able to stand after completion of anesthesia to the time at which the animal is allowed to walk freely. Dogs are permitted free movement in a large pen; horses are walked with a halter for 10 to 20 minutes.

water is available, some dogs will attempt to drink as soon as they can raise their heads. This is particularly true when ether anesthesia has been employed. Although some veterinarians withhold water, most dogs receive it within 4 to 6 hours after recovery from anesthesia. Dogs are usually fed during the first 12-hour period, although some veterinarians prefer to withhold food for 24 hours following surgery. A survey of 25 veterinarians indicates that the usual practice following herniorrhaphy is to allow food within 4 to 24 hours. Except in cases of gastrointestinal surgery, no special diet is employed. Ordinarily, dogs present no special problem with postsurgical urination and defecation. In a survey of 100 cases of major surgery, it was found that a high percentage of dogs urinated within the first postsurgical hour, and that the first defecation occurred between the first and twenty-fourth hour.

Except for restraint in a cage or stall, it is impracticable to attempt to control activity in animals during the immediate postsurgical period. In the Veterinary Hospital, University of Pennsylvania, some dogs are allowed to exercise in a pen during the 12-hour period after surgery, and nearly all animals are allowed this activity within 24 hours. Horses are able to move about freely in box stalls and usually are given daily walking exercise for periods of 10 to 20 minutes during the first 48 hours.

In summary, most animals stand, move about, eat, and drink within a few hours after surgery. Moderate exercise is allowed within the first 24 to 48 hours.

Subsequent Convalescent Period

The ultimate goal for animals after any surgical operation is a rapid return to regular activity or production. This is particularly true of the animal with economic value. The dairy cow that is not producing its normal quantity of milk and the race horse not in racing condition are liabilities to the owners.

In the study summarized in FIGURE 2, data were obtained from 25 veterinarians engaged in small animal practice and from 5 in equine practice. The practitioners were questioned concerning their approach to postsurgical exercise in animals. Data was obtained on three groups of dogs—greyhounds, working dogs, and nonworking dogs—and three groups of horses—flat racers, steeplechasers, and hunters.

Greyhound dogs. The primary activity of the greyhound is racing. A survey of two veterinarians on approximately 1500 cases indicates that, after uncomplicated total hysterectomy, greyhounds are able to return to the race track in 2 weeks. The significance of this may be appreciated when it is pointed out that, on returning to the track, the dog may race for a distance of up to one-half mile at a speed of approximately 35 miles per hour.

Working and nonworking dogs. Data on these groups of dogs were obtained from records in the Veterinary Hospital, University of Pennsylvania, and from 25 practitioners. A total of 200 cases is included in the study. Working dogs are animals used for hunting purposes; nonworking dogs are household pets. The survey revealed that in both of these groups light exercise was permitted within 2 to 7 days, with an average of four days, following umbilical or inguinal herniorrhaphy. Light exercise includes walking on the leash or free activity within a relatively confined space, as in the home or a large pen. Within 4 to 9 days, with an average of seven days, the nonworking dog is allowed moderate exercise, while the working dog is permitted this level of exercise within 7 to 14 days, with an average of ten days, after surgery. Moderate exercise in both groups includes free activity, the only restriction being that the animal does not become exhausted. For example, the hunting dog may be taken into the field and allowed to run for periods up to 1 hour. Full exercise after surgery is allowed the nonworking dog in an average of 14 days and, for the working dog, in an average of 17 days. For the nonworking animal, this refers to completely unrestricted activity. For the working dog, a return to full exercise indicates that the animal is allowed unrestricted activity in the hunting field.

Horses. Five veterinarians engaged in equine practice were questioned concerning management of the convalescent horse. A total of 154 cases is contained in the survey. All 5 practitioners indicated no significant difference in their approach to the convalescent horse, whether the animal is used for flat racing, steeplechase racing, or hunting. Light exercise is begun within 3 to 10 days, with an average of 7 days. This includes freedom to move about in a relatively restricted area such as a paddock, and in some cases even slow jogging with a rider. Moderate exercise, including running for short periods with a rider, is allowed in 14 to 21 days, with an average of 18 days. One veterinarian indicated that he would not allow full activity, that is, full train-

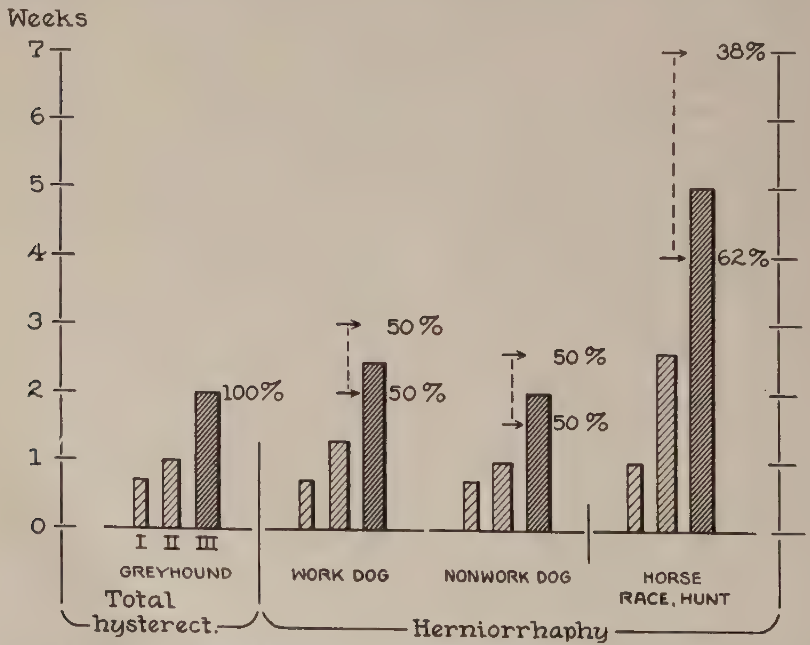

Figure 2. Average periods after surgery required by animals prior to a return to various levels of exercise: I denotes light exercise; II, moderate exercise; and III, full exercise. The height of each column represents average values; percentage figures indicate the number of cases represented at the upper and lower limits of the range.

ing for racing or hunting, for 7 weeks following surgery, while 4 others reported that unrestricted activity could begin in 4 weeks. The extent of this activity can be appreciated when it is realized that a race horse may carry from 125 to 200 pounds of weight and that a hunter takes 4-foot jumps on uneven terrain.

This survey makes it evident that the current practice is to allow a longer period of time between surgery and full activity in the horse than in the dog. One explanation for this difference might be variations in body weight; that is, animals with a greater body weight recover more slowly. However, this seems unlikely because animals with great differences in body weight, such as the goat and cow, recover from major surgery at approximately the same rate. A more logical explanation of the variation in recovery time between horse and dog may be found in practical considerations. Training schedules for horses are far more carefully regulated than those for dogs, and it seems likely that both the veterinarian and the horse trainer will be somewhat more conservative in their approach to convalescence in the horse. An additional economic factor enters in some cases. In supervising the convalescence of a horse worth $25,000, the natural tendency is toward greater conservatism than would be observed in that of a hunting dog worth $100.

Summary

Surgical convalescence in animals is characterized by a rapid return to full activity. Dogs such as greyhounds return to competitive racing in 2 weeks following total hysterectomy, and race horses are in full training within 4 weeks after a ventral herniorrhaphy.

In contrast to man, lower animals exhibit spontaneous activity immediately after recovery from anesthesia. Generally, animals are placed on a full diet within 24 hours after surgery, and water consumption may begin as early as the first postanesthetic hour.

Some of the features of surgical convalescence in animals are undoubtedly related to the inherent behavorial characteristics of the species. However, others are induced by certain practical considerations, particularly the necessity of returning the economically important animal to full activity and production as soon as possible. Clinical experience indicates that after uncomplicated major surgery this can be accomplished without harm to the future usefulness of the animal. In view of the rapid convalescence of animals, basic studies on the lower types might be expected to contribute to a better understanding of the relationship of homeostasis to the rate of return to full activity.

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THE DURATION OF SURGICAL CONVALESCENCE AS INDICATED BY INSURANCE STATISTICS

By Harvey J. Saffeir
The Travelers Insurance Company, Hartford, Conn.

Many accident and health underwriters, including my own firm, The Travelers Insurance Company, offer a group insurance coverage, which is generally referred to in the industry as weekly indemnity. This coverage provides for the payment of a weekly income when an insured person becomes disabled. Such sickness income usually begins after a short waiting period and continues for the period of disability, up to a maximum of 3 months, 6 months, or a year, depending on the plan purchased.

Whenever a claim is made, we prepare a punch card containing identifying information and certain statistics important for our accounting. Occasionally we make a special study of claims to see if there have been any changes in the characteristics of particular claims. For this purpose a sample of claims is coded more thoroughly to obtain information regarding the cause of disability, whether there was surgery, the date surgery was performed, the duration of disablement, the amount of disability income, the wage, where the disability took place, and other similar questions. The information is then transferred to punch cards. It is from such a sample that the information in this paper and in the accompanying figures is derived.

Three of the most common surgical procedures are discussed, namely, appendectomy, herniorrhaphy, and hemorrhoidectomy. For each of these three procedures a distribution of the claims in the sample is shown by the duration of surgical convalescence. In order to indicate whether there have been any significant changes in the length of surgical convalescence over the past few years, two samples are presented, one from 1957 and the other from 1955. The figures show distributions and durations for male claims only, because the data for females are relatively sparse owing to the fact that about three quarters of the employees who are covered by our group policies are male.

FIGURE 1*a* illustrates surgical convalescence in male hemorrhoidectomies that were done in 1957. The duration of surgical convalescence is shown on the horizontal scale and the percentage of the sample on the vertical scale. Clearly, the most common duration of surgical convalescence is 3 weeks. The range is from 3 days to 14 weeks, and the average stay is 4 weeks. Incidentally, by 4 weeks I mean durations of from 25 to 31 days with 28 days or 4 weeks at the center.

FIGURE 1*b* also illustrates male hemorrhoidectomies, the difference being that the sample is from the year 1955. The distribution is very similar to that of the 1957 sample. The most common duration is also 3 weeks, the average is again 4 weeks, and the range is from 1 week to more than 10 weeks. Durations of 10 weeks and more in the 1955 surgical sample are combined. It appears that there has been a slight decrease in the average duration of hemor-

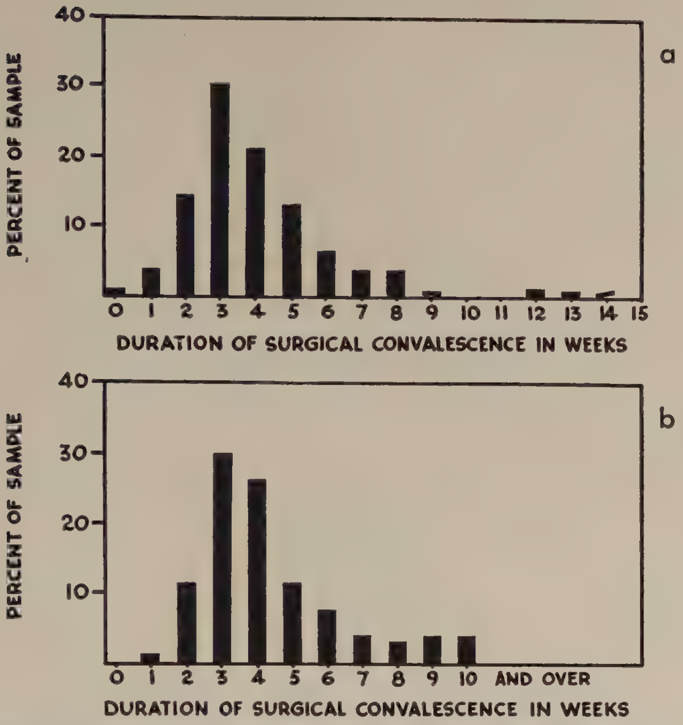

FIGURE 1. Male hemorrhoidectomy convalescence: (*a*) 1957 sample; average duration, 4 weeks; highest frequency, 3 weeks; range, 3 days to 14 weeks; and (*b*) 1955 sample; average duration, 4 weeks; highest frequency, 3 weeks; range, 1 week to more than 10 weeks.

rhoidectomies over the 2-year period. In contrast with *a*, *b* shows a slight shifting to the left toward shorter durations.

With respect to surgical convalescence in herniorrhaphies, FIGURE 2*a* is a sample from 1957. The most common duration is 6 weeks, the average is 6½ weeks, and the range is from 7 days to 15 weeks. FIGURE 2*b* shows herniorrhaphy data for operations performed in 1955. Although at first glance the data for 1955 do not seem to resemble those for 1957 (FIGURE 2*a*), actually there is a significant similarity. The last column of FIGURE 2*b* is for 10 or more weeks. If the 10 or more weeks were shown week by week, they would taper off just as they do in FIGURE 2*a*. The significant fact is that, in both, the most common durations are very close. In the 1957 sample the average has shifted slightly to the left. Moreover, both 1955 and 1957 samples show a wide range in the length of convalescence.

The duration of convalescence in appendectomies (FIGURE 3) can be compared with the range shown for hemorrhoidectomies and herniorrhaphies. FIGURE 3*a* indicates that the average duration in 1957 is 5 weeks. The most common duration is either 4 or 3 weeks, and the range is from 8 days to 14 weeks. The 1955 sample of appendectomies shown in FIGURE 3*b* is somewhat similar. Here, too, the average is 5 weeks, the highest frequency is 4 weeks,

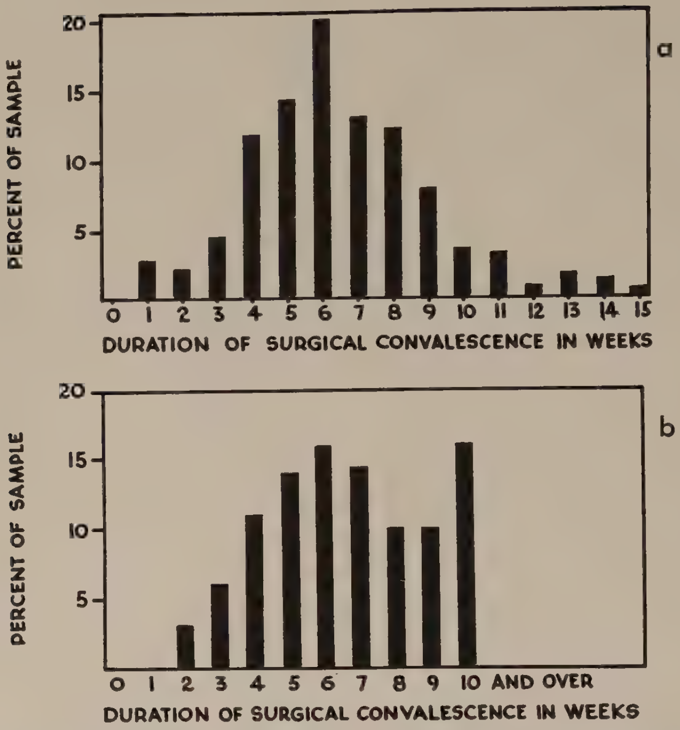

FIGURE 2. Male herniorrhaphy convalescence: (*a*) 1957 sample; average duration, 6½ weeks; highest frequency, 6 weeks; range, 1 week to 15 weeks; (*b*) 1955 sample; average duration, 7 weeks; highest frequency, 6 weeks; range, 2 weeks to more than 10 weeks.

and the range is from 2 weeks to more than 10 weeks. Some of the four-week durations of the 1955 sample are shortened to 3 weeks in the 1957 sample, which implies a slight reduction in the duration of convalescence from appendectomies, although the arithmetical average is still about 5 weeks.

It may now be seen that for the three surgical procedures under discussion there has been a slight decrease in the duration of surgical convalescence between 1955 and 1957. There is a wide range in these durations of from 1 or 2 weeks to 15 weeks. The most frequent durations are 3 weeks for hemorrhoidectomies, 6 weeks for herniorrhaphies, and 3 or 4 weeks for appendectomies.

It should be pointed out that an analysis of the statistics available to us indicates that the female surgical convalescence durations have a range at least as wide as those of the males. We have also found that the average length of surgical convalescence is significantly higher for females than for males: for appendectomy, about 15 per cent longer than for the male, about 40 per cent longer for herniorrhaphy, and about 30 per cent longer for hemorrhoidectomy.

Why is it that one person stays out of work for only 2 weeks and another

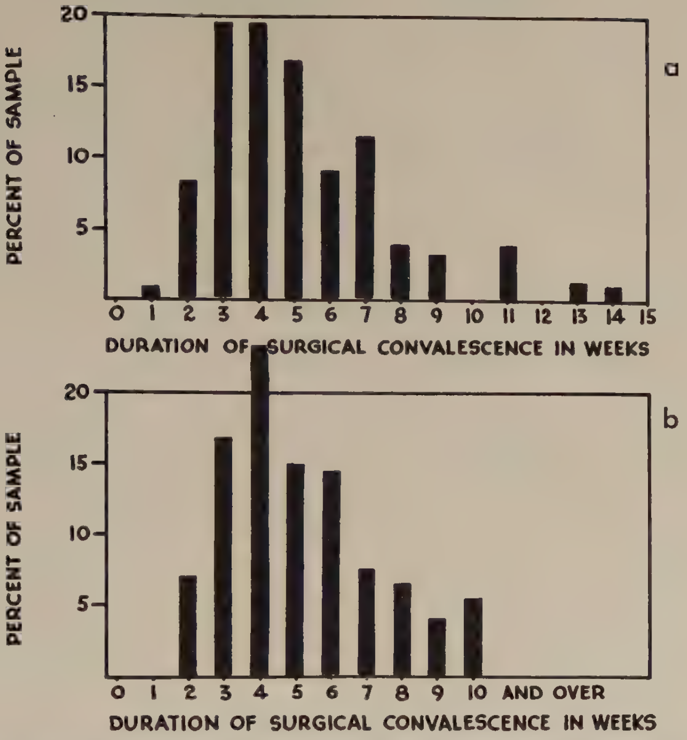

FIGURE 3. Male appendectomy convalescence: (*a*) 1957 sample; average duration, 5 weeks; highest frequency, 4 weeks; range, 1 week to 14 weeks; and (*b*) 1955 sample; average duration, 5 weeks; highest frequency, 4 weeks; range, 2 weeks to more than 10 weeks.

for as long as 10? Certain influences relevant to this question are difficult to measure in a study of this sort. One of these is the desire of the employee to return to work out of a sense of responsibility, liking for the work, and other similar considerations. We were unable to investigate this point directly, although we do have certain indirect data. A second feature that we were unable to pursue in this study was the effect of light labor and heavy labor on duration. In the 1955 investigation a claim sample of one procedure was separated into those doing light labor and those doing heavy labor. The latter had a surgical convalescence period 50 per cent longer than those in light labor.

Certain influences, however, can be measured directly from the given statistics. These include age, personal economic factors, and geographical region.

For the first of these, namely, the effect of age on the duration of surgical convalescence, FIGURE 4 shows the variation in duration of each of the 3 operations. Because the 1957 sample was so similar to that for 1955, only the figures for 1957 are presented. One would expect that the duration of surgical convalescence would increase with advancing age. Let us see to what extent this is true.

In FIGURE 4 average duration is given on the vertical scale. As shown in FIGURE 4*a*, the variation in average duration of convalescence after hemorrhoidectomy is roughly from 22 days at 25 years of age to approximately 30 days at 65 years of age, a difference of about 1 week. The average for herniorrhaphies (FIGURE 4*b*) ranges from approximately 42 days at 25 years of age to roughly 50 days at 65 years of age—again about 1 week's difference. For appendectomies, FIGURE 4*c* shows the average ranges from about 37 days at 25 years of age to roughly 45 days at 65 years of age—again a range of about 1 week. This indicates that there is an upward trend in the duration of surgical convalescence as age advances. However, while the differences in duration by age are significant, they are not sufficient in themselves to explain the very wide difference in surgical convalescence duration apparent in FIGURES 1, 2, and 3.

It has already been suggested that personal economic factors might influence the duration of surgical convalescence. In FIGURE 5 the duration of surgical convalescence is compared with the weekly indemnity or disability income received by those insured while convalescing. One might think that as the amount of sickness income increases, there would be a tendency for the employee to remain away from work for a longer time. FIGURE 5*a*, the scale for hemorrhoidectomy, indicates that there is hardly any change between the figures for those receiving $20 and $50 of weekly sickness income. The figures for less than $20 and for $60 and over constitute very few claims, and should not be given too much weight. The remaining points indicate a horizontal line.

FIGURE 5*b*, the scale for herniorrhaphy, which includes a rough total of 225 claims, indicates that there is no increase in duration from lower weekly sickness income to higher weekly sickness income. Here again, it should be pointed out that the figure for less than $20 per week and that for $60 and over should be given relatively little weight. If there is any trend, it is downward. In the case of appendectomy (FIGURE 5*c*), the duration seems to fall as the amount of weekly sickness income increases. On the whole, the duration of surgical convalescence appears not to increase; it may even decrease slightly as the amount of weekly sickness income increases.

Since a weekly indemnity is usually a percentage of wage, this slight decrease suggests that there may be a tendency for more highly paid employees to return to work sooner than the employees with lower wages. A comparison of the duration of surgical convalescence with the amount of weekly wage is illustrated in FIGURE 6. Claims in which salary information was furnished are divided into three classes: a low wage group—those earning less than $70 a week; an average wage group—those earning from $70 to $90 a week; and a higher wage group—those earning $90 or more. The most interesting aspect is that there seems to be no relation between the duration of surgical convalescence and the amount of weekly wage. In hemorrhoidectomy (FIGURE 6*a*) the average duration is between 27 and 29 days for each of the 3 wage groups; in herniorrhaphy (FIGURE 6*b*) the range is from 45 to 47 days, and in appendectomy (FIGURE 6*c*), from 36 to 38 days.

A comparison of claims with respect to the relationship between the duration

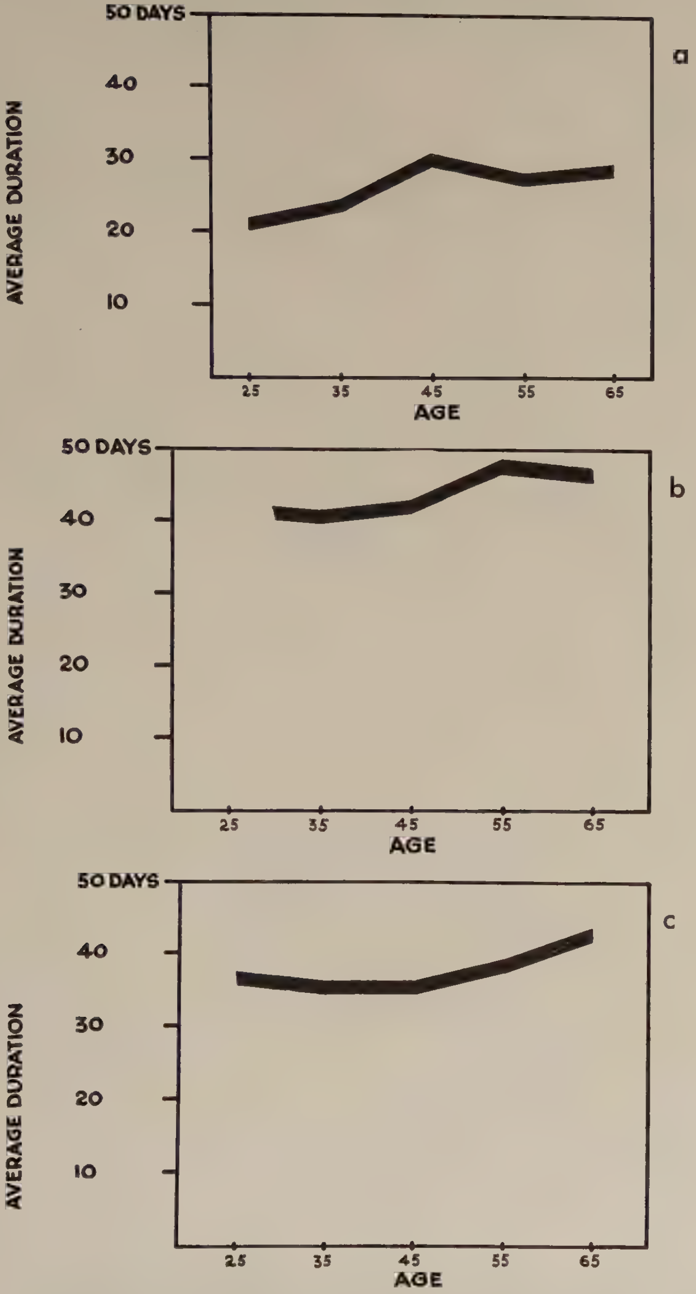

FIGURE 4. The effect of age on the duration of surgical convalescence in the male in (*a*) hemorrhoidectomy, (*b*) herniorrhaphy, and (*c*) appendectomy.

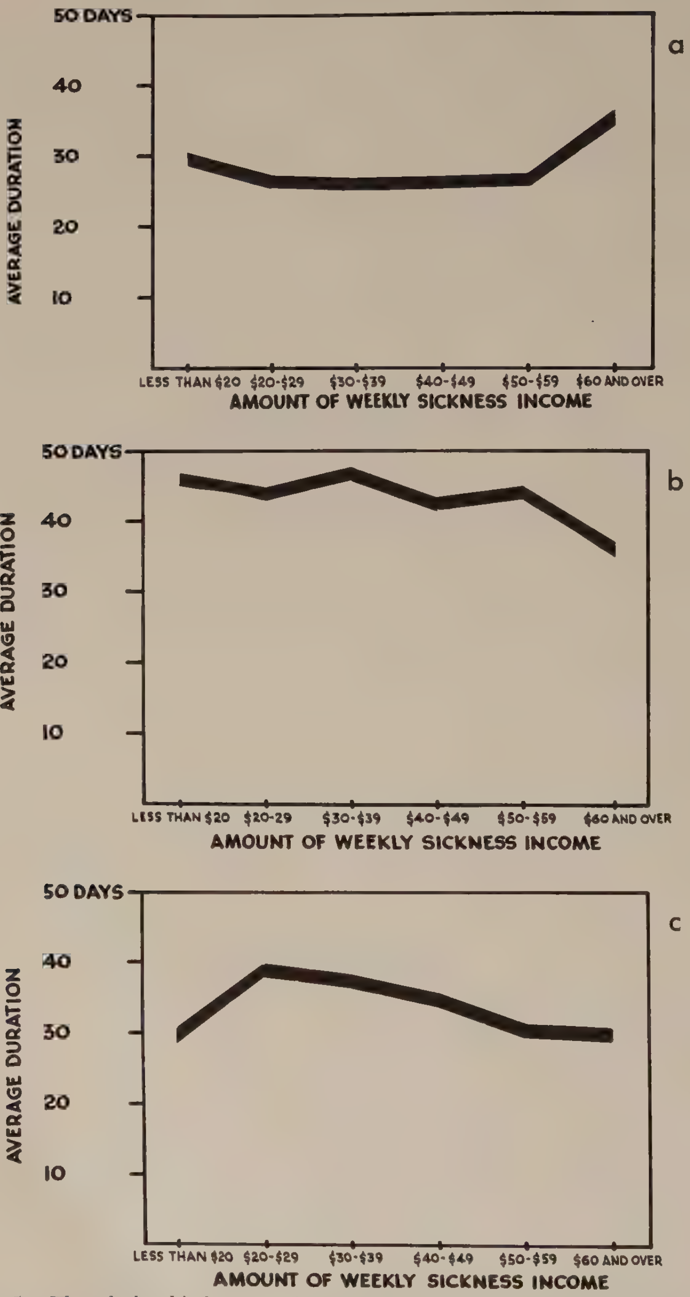

FIGURE 5. The relationship between the duration of convalescence claims and the amount of weekly sickness income for (*a*) hemorrhoidectomy, (*b*) herniorrhaphy, and (*c*) appendectomy.

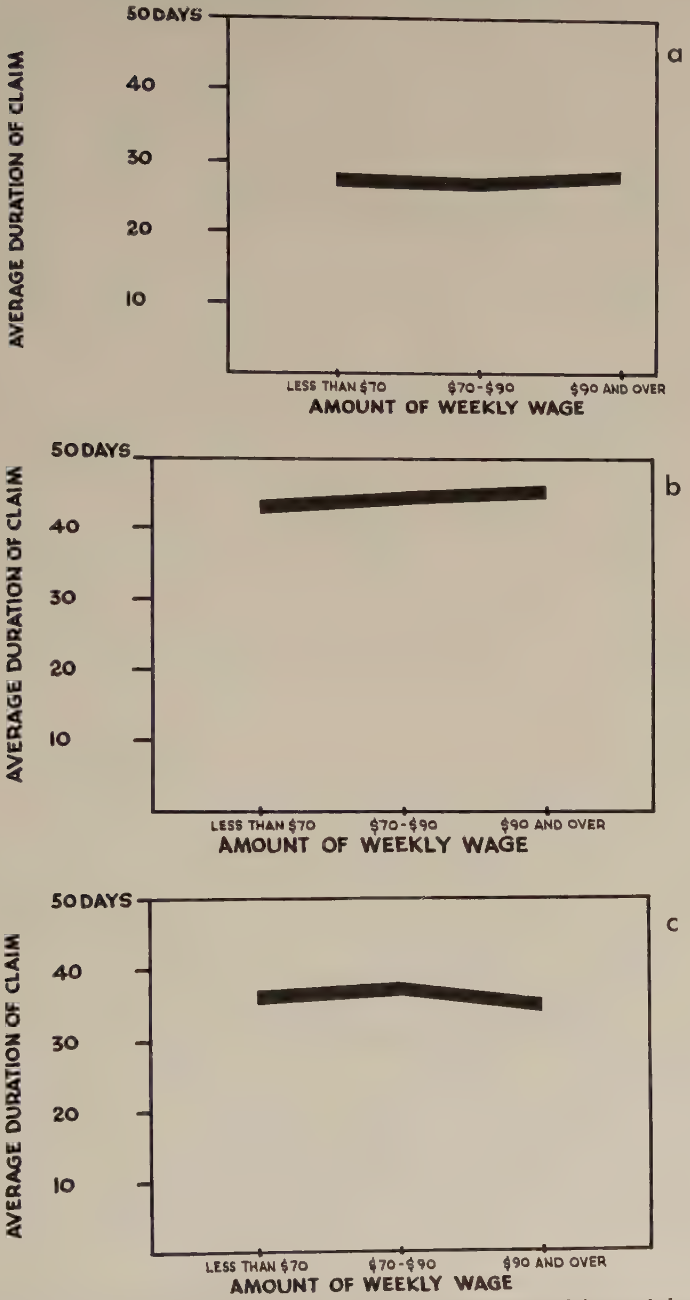

FIGURE 6. The relationship between the duration of convalescence claims and the amount of weekly wage for (*a*) hemorrhoidectomy, (*b*) herniorrhaphy, and (*c*) appendectomy.

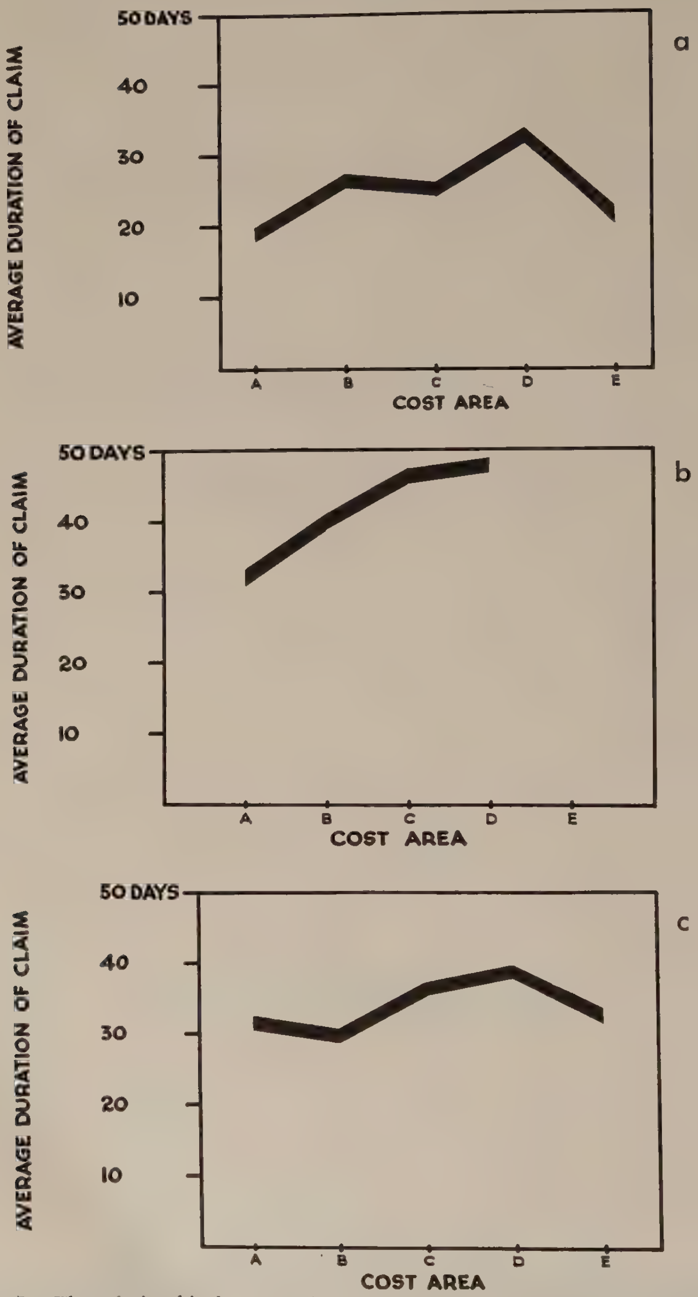

FIGURE 7. The relationship between the duration of convalescence claims and medical costs in various sections of the country (the cost areas are the lowest at A and the highest at E) for (*a*) hemorroidectomy, (*b*) herniorrhaphy, and (*c*) appendectomy.

of surgical convalescence and the percentage of salary being replaced by the weekly indemnity produced no apparent trends.

It seems, therefore, that personal economic factors, that is, the sickness income, the wage, and the relationship between the two, have very little influence on the duration of surgical convalescence.

The wide variations in the duration of surgical convalescence that we have noted could be related to medical costs in various sections of the country. To test this hypothesis the data were divided into 5 medical cost regions which, in FIGURE 7, are labeled A, B, C, D, and E. A represents the lowest cost area and E, the highest. Area A, for example, includes the low medical-cost states of Mississippi, Alabama, Georgia, South Carolina, and Arkansas; area C includes such states as Illinois, Indiana, New Jersey, and Ohio; and area E, which has the highest costs, includes Rhode Island, California, Oregon, and Washington, among others.

FIGURE 7*a* demonstrates that the range is fairly wide. The points with the most data are areas C and D. There are relatively few claims in A and E. On the whole, it seems that there is an upward trend in duration as medical care costs increase.

With regard to herniorrhaphy (FIGURE 7*b*), the most significant points again are C and D, where there is a slight upward trend. The other points represent relatively few claims and are, therefore, less reliable; nevertheless, the trend is definitely upward.

The comparison for appendectomy (FIGURE 7*c*) shows that the duration in all 5 areas falls between 30 and 40 days. The 3 most significant points are for areas B, C, and D and, within the range of those points, there is an upward trend.

For these 3 impairments, at any rate, it appears that as the costs of medical care increase there is a tendency for the duration of surgical convalescence to increase. This tendency may be due to several different factors, of which the medical care costs are merely an index. The increase by area, however, is generally only a matter of a few days, and cost area alone certainly cannot explain the wide variations shown in FIGURES 1, 2, and 3.

In the last few years there has been a change in the duration of hospital confinement. On the basis of the hospital claims of male in-patients for all causes combined, we have found that the average stay only a few years ago was about 9 days. More recent studies indicate a somewhat shorter stay—slightly more than 8 days. One might assume that this is due to shortened hospital stays after surgery, but shorter stays after surgery may not be the only reason for shorter average stays. For instance, we have found that during this period the frequency of utilization of in-patient hospital services has increased. This added utilization is primarily a result of more *short-term* claims. It may well be that, for those cases that in former years would have resulted in hospitalization, the duration of hospital stay has not in fact decreased as much as might be indicated by the aforementioned change in average length of stay.

In summary, it has been shown that there is a wide variation in the duration of surgical convalescence. There has been a slight decrease in the duration of surgical convalescence between 1955 and 1957. Increasing age has some effect on duration, but the amount of sickness income, the wage of the employee, and the relationship between the two seem to be of little or no significance. The medical cost area seems to be of some importance. It would appear, therefore, that influences other than those just mentioned have a significant effect on the wide variations in the duration of surgical convalescence.

SURGICAL CONVALESCENCE: WHEN DOES IT END?*

By N. Henry Moss
Harrison Department of Surgical Research and Department of Surgery, School of Medicine, University of Pennsylvania; the Albert Einstein Medical Center, Philadelphia, Pa.

F. Curtis Dohan
Department of Medicine, School of Medicine, University of Pennsylvania, Philadelphia, Pa.

The opinion of the doctor appears to play the major role in determining the duration of surgical convalescence in uncomplicated cases. On the other hand, analysis of the responses to a questionnaire reveals that there is a wide diversity of opinion among physicians concerning the optimum duration of surgical convalescence.[1] No adequate criteria exist for defining the period of total convalescence. This has been confirmed by a search of the literature, by the wide diversity of opinion revealed in our survey, and by informal discussions with many physicians and surgeons. Physician management of patients in the latter phases of surgical convalescence appears to be based on impressions and vague concepts, rather than objectively supported evidence.

FIGURES 1, 2, and 3 show the questionnaire sent to a nationwide sample of four groups of physicians. It requested information concerning their current practice in returning patients to defined light and heavy work in uncomplicated cases under specified conditions and for operations of limited magnitude. These physician groups were: professors of surgery; a random selection of general surgeons certified by the American Board of Surgery;† gynecologists certified by the American Board of Gynecologists and Obstetricians;‡ industrial physicians; and general practitioners from the American Academy of General Practice.§

FIGURE 4 demonstrates that, for the same hypothetical case, the recommended interval for return to light work after appendectomy varied from 5 to 30 days with an average of 14 days, and to heavy work from 7 to 60 days with an average of 28 days. A similar wide range of opinion was also expressed for hemorrhoidectomy (FIGURE 5) and cholecystectomy (FIGURE 6). After inguinal herniorrhaphy (FIGURE 7) in a 50-year-old patient, the recommended time to return to light work ranged from 7 days to as long as 84 days with an average of 24 days, and for heavy work from 21 days to 180 days. This wide diversity of opinion indicates a lack of adequate criteria for determining the optimum duration of surgical convalescence.

The results of the survey on the convalescent period after gynecological procedures show the same wide diversity of opinion among physicians. Certified gynecologists and general practitioners were queried regarding return to light or heavy activity in hypothetical cases and their answers show that for even a simple procedure in a 45-year-old woman such as dilatation and curet-

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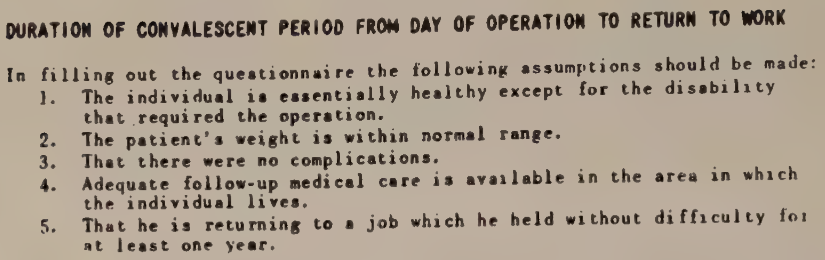
* This is the second, more detailed, study on this subject.
† Office of the Executive Secretary, Philadelphia, Pa.
‡ Office of the Executive Secretary, Cleveland, Ohio.
§ Office of the Executive Secretary, Kansas City, Kans.

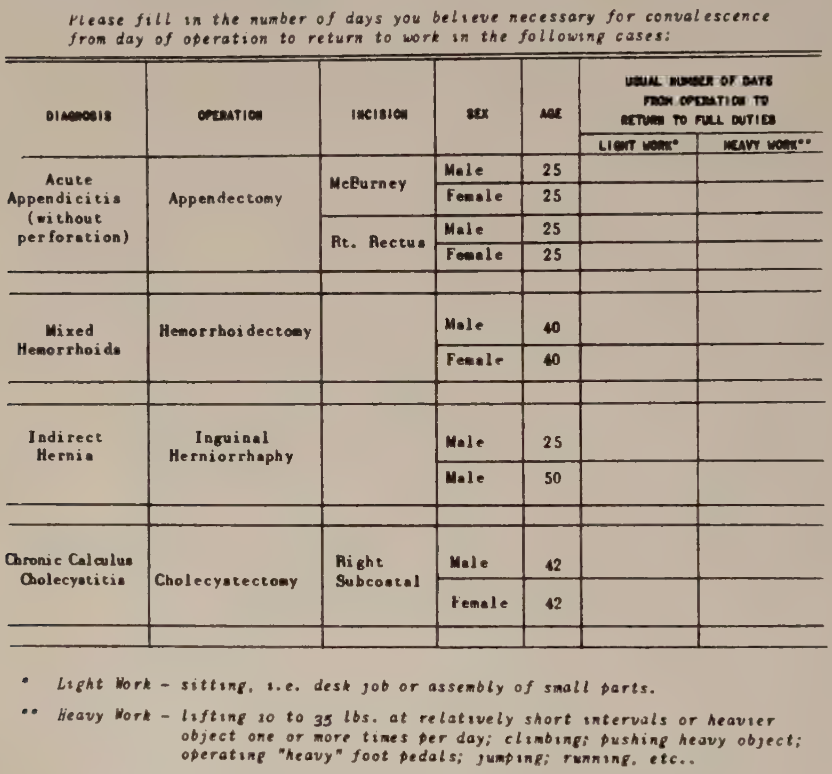


DURATION OF CONVALESCENT PERIOD FROM DAY OF OPERATION TO RETURN TO WORK

In filling out the questionnaire the following assumptions should be made:

1. The individual is essentially healthy except for the disability that required the operation.
2. The patient's weight is within normal range.
3. That there were no complications.
4. Adequate follow-up medical care is available in the area in which the individual lives.
5. That he is returning to a job which he held without difficulty for at least one year.

FIGURE 1. Directions for filling out the questionnaire on surgical convalescence. Reproduced by permission from Moss *et al.*[1]



Please fill in the number of days you believe necessary for convalescence from day of operation to return to work in the following cases:

DIAGNOSIS	OPERATION	INCISION	SEX	AGE	USUAL NUMBER OF DAYS FROM OPERATION TO RETURN TO FULL DUTIES	
					LIGHT WORK*	HEAVY WORK**
Acute Appendicitis (without perforation)	Appendectomy	McBurney	Male	25		
			Female	25		
		Rt. Rectus	Male	25		
			Female	25		
Mixed Hemorrhoids	Hemorrhoidectomy		Male	40		
			Female	40		
Indirect Hernia	Inguinal Herniorrhaphy		Male	25		
			Male	50		
Chronic Calculus Cholecystitis	Cholecystectomy	Right Subcostal	Male	42		
			Female	42		

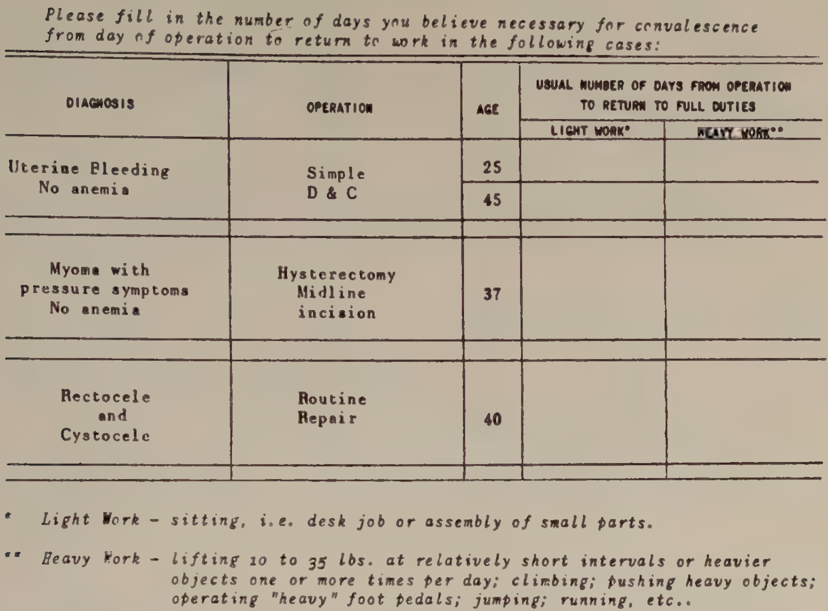
* *Light Work - sitting, i.e. desk job or assembly of small parts.*

** *Heavy Work - lifting 10 to 35 lbs. at relatively short intervals or heavier object one or more times per day; climbing; pushing heavy object; operating "heavy" foot pedals; jumping; running, etc..*

FIGURE 2. Section of the questionnaire on the duration of surgical convalescence.

tage, a wide disparity of opinion exists (FIGURE 8). A slightly shorter average convalescent period than noted in FIGURE 8 was considered necessary for a 25-year-old woman undergoing the same operation. The age of the patient plays only a minor role in determining the physician's opinion concerning duration of convalescence.[1]

For hysterectomy, the recovery period averaged 29 days before return to light work and 50 days before return to heavy work, in the opinion of physicians queried (FIGURE 9). Again, one notes the wide spread of opinion for the



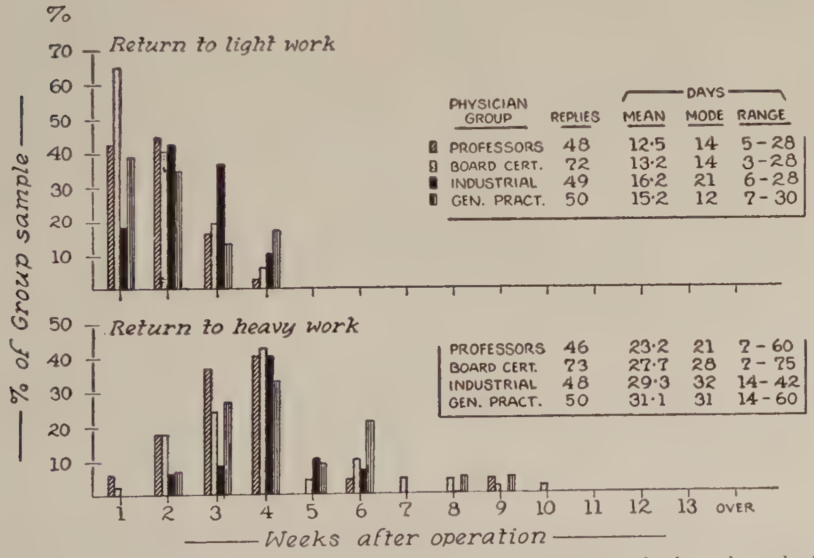
Please fill in the number of days you believe necessary for convalescence from day of operation to return to work in the following cases:

DIAGNOSIS	OPERATION	AGE	USUAL NUMBER OF DAYS FROM OPERATION TO RETURN TO FULL DUTIES	
			LIGHT WORK*	HEAVY WORK**
Uterine Bleeding No anemia	Simple D & C	25		
		45		
Myoma with pressure symptoms No anemia	Hysterectomy Midline incision	37		
Rectocele and Cystocele	Routine Repair	40		

* *Light Work - sitting, i.e. desk job or assembly of small parts.*

** *Heavy Work - lifting 10 to 35 lbs. at relatively short intervals or heavier objects one or more times per day; climbing; pushing heavy objects; operating "heavy" foot pedals; jumping; running, etc..*

FIGURE 3. Section of the questionnaire on the duration of surgical convalescence. Reproduced by permission from Moss *et al.*[1]



	PHYSICIAN GROUP	REPLIES	DAYS MEAN	DAYS MODE	DAYS RANGE
▨	PROFESSORS	48	12·5	14	5-28
▯	BOARD CERT.	72	13·2	14	3-28
■	INDUSTRIAL	49	16·2	21	6-28
▥	GEN. PRACT.	50	15·2	12	7-30

PHYSICIAN GROUP	REPLIES	MEAN	MODE	RANGE
PROFESSORS	46	23·2	21	7-60
BOARD CERT.	73	27·7	28	7-75
INDUSTRIAL	48	29·3	32	14-42
GEN. PRACT.	50	31·1	31	14-60

FIGURE 4. Distribution of recommended intervals for return to work after a hypothetical appendectomy in a patient 25 years old. Reproduced by permission from Moss *et al.*[1]

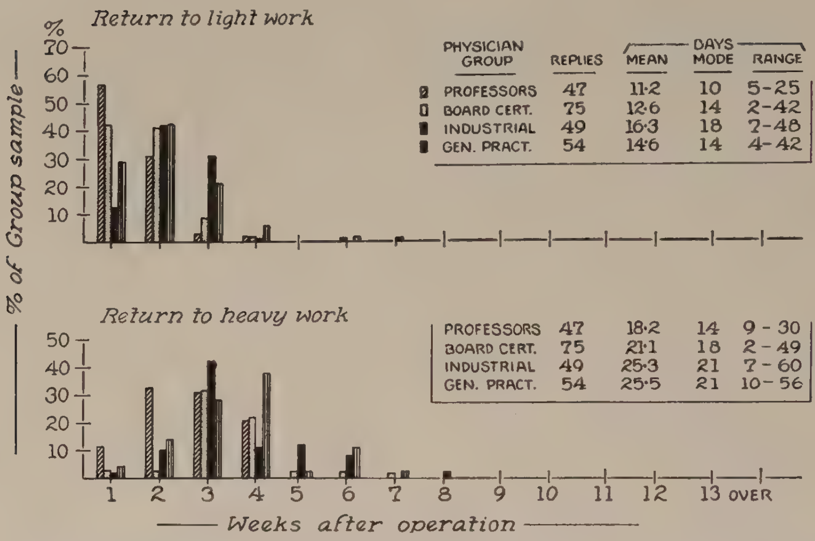


FIGURE 5. Distribution of recommended intervals for return to work after hemorrhoidectomy in a patient 40 years old.

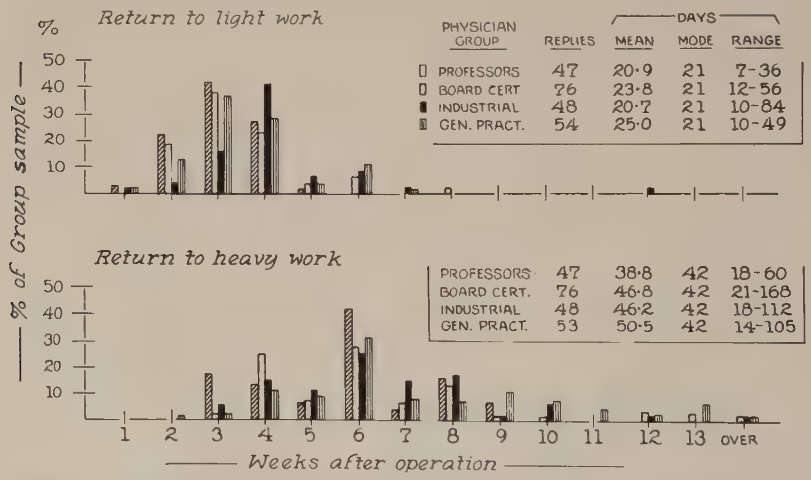
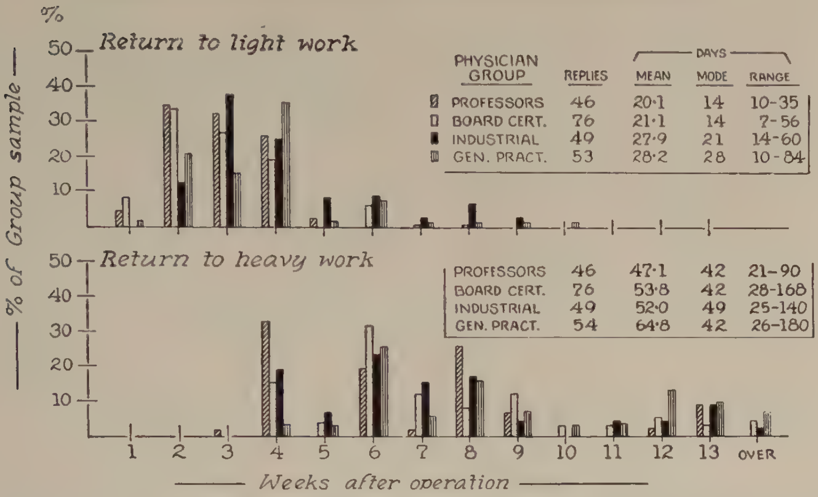


FIGURE 6. Distribution of recommended intervals for return to work after subcostal cholecystectomy in a patient 42 years old.

two groups of physicians for this same hypothetical case. There is a relatively close correlation in this instance between the opinions of general practitioners and those of gynecologists. For the general surgical procedures previously demonstrated, the general practitioners and industrial physicians tended to recommend return somewhat later than did the surgeons.

FIGURE 10 reveals an equally wide divergence of opinion for the convalescent period after perineal plastic repair of rectocele and cystocele. In this instance



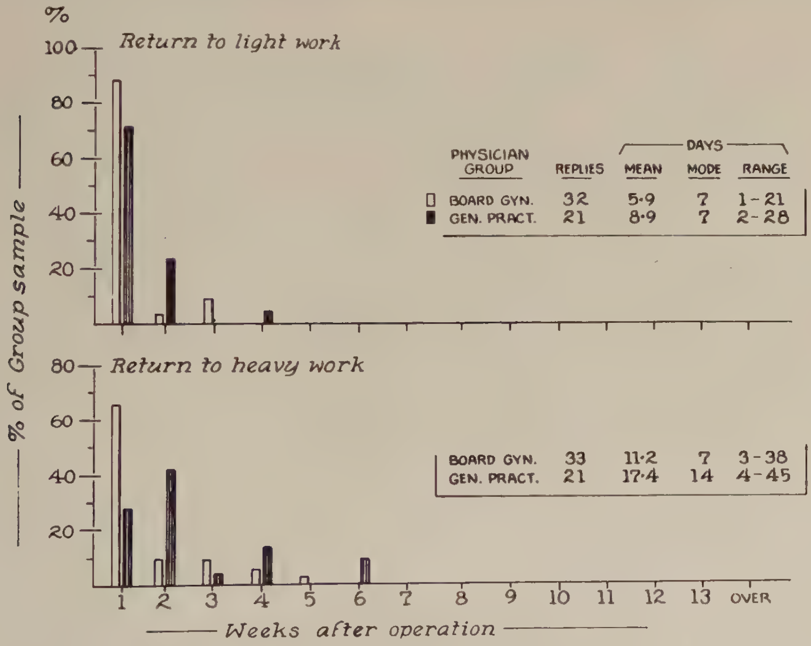
Return to light work

PHYSICIAN GROUP	REPLIES	DAYS MEAN	DAYS MODE	DAYS RANGE
▨ PROFESSORS	46	20·1	14	10-35
☐ BOARD CERT.	76	21·1	14	7-56
■ INDUSTRIAL	49	27·9	21	14-60
▥ GEN. PRACT.	53	28·2	28	10-84

Return to heavy work

PHYSICIAN GROUP	REPLIES	DAYS MEAN	DAYS MODE	DAYS RANGE
PROFESSORS	46	47·1	42	21-90
BOARD CERT.	76	53·8	42	28-168
INDUSTRIAL	49	52·0	49	25-140
GEN. PRACT.	54	64·8	42	26-180

FIGURE 7. Distribution of recommended intervals for return to work after inguinal herniorrhaphy in a patient 50 years old.



Return to light work

PHYSICIAN GROUP	REPLIES	DAYS MEAN	DAYS MODE	DAYS RANGE
☐ BOARD GYN.	32	5·9	7	1-21
■ GEN. PRACT.	21	8·9	7	2-28

Return to heavy work

PHYSICIAN GROUP	REPLIES	DAYS MEAN	DAYS MODE	DAYS RANGE
BOARD GYN.	33	11·2	7	3-38
GEN. PRACT.	21	17·4	14	4-45

FIGURE 8. Distribution of recommended intervals for return to work after simple dilatation and curettage in a patient 45 years old.

the mean number of days lost before return to light work was 31. The average time lost before return to heavy activity was 53 days.

In a study of the opinions of 200 nonprofessional people concerning the duration of convalescence before return to light work after appendectomy, we

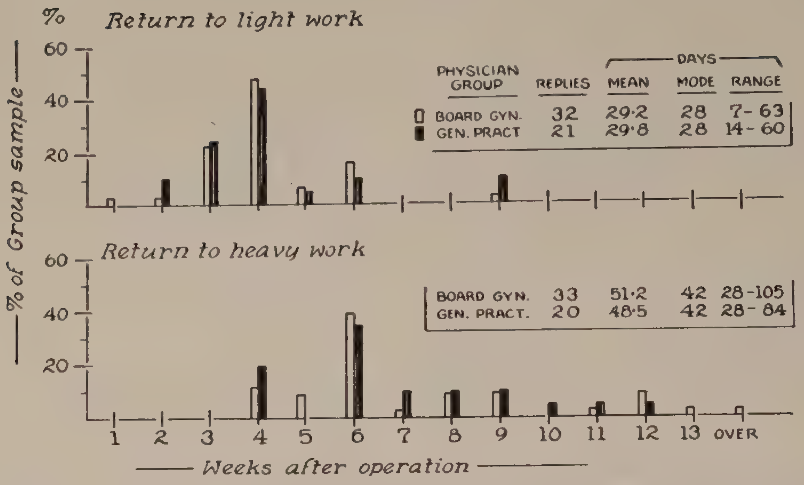


FIGURE 9. Distribution of recommended intervals for return to work after hysterectomy in a patient 37 years old.

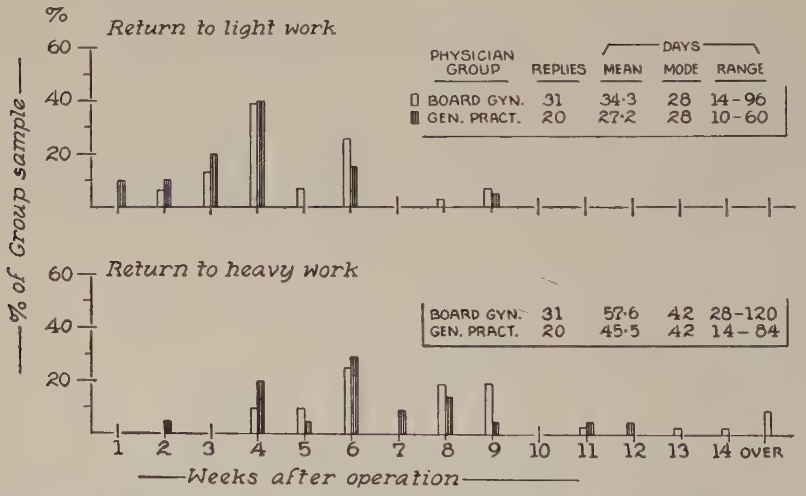


FIGURE 10. Distribution of recommended intervals for return to work after routine repair of rectocele and cystocele in a patient 40 years old. Reproduced by permission from Moss *et al.*[1]

found an even wider spread of opinion than that shown in FIGURE 4. The range was from 1 to 12 weeks.

Maximum wound strength is obtained in 2 to 3 weeks. In the classic work of Howes *et al.*[2] one notes that 95 per cent of the maximum tensile strength of the wound in animals is achieved within this time in normal healing. Therefore, fear of disruption of the wound after the third week in uncomplicated cases is ill-founded. Elsewhere in this monograph F. D. Moore and J. D.

Hardy have thoroughly reviewed the metabolic and neuroendocrine changes that take place postoperatively, correlating these changes with the duration and phases of convalescence. There appears to be little reason from their data for metabolic and neuroendocrine abnormalities to account for such prolonged periods of convalescence in uncomplicated cases.

On the other hand, there is evidence for the concept that earlier return to preoperative activity is not only safe, but may provide increased physiological and psychological, as well as economic, benefits. Recent experience of the military has indicated that it is safe to return the individual to full duty after a considerably shorter period of convalescence than is current civilian practice.

D. S. Wenger,[3] Medical Corps, the United States Air Force, in July, 1956 published an analysis of the experience of the Air Force in returning personnel to full duty following common surgical procedures. These data showed striking differences from civilian practice. David Gold's article elsewhere in this monograph, which analyzes more recent Air Force experience, indicates even shorter convalescent time. The convalescent times after appendectomy, inguinal herniorrhaphy, and hemorrhoidectomy are approximately one third those of current civilian practice when judged by the reports of H. J. Saffeir and A. J. Fleming in this monograph.

At a "boot training camp", S. Spoont (personal communication) studied a group of 69 United States Navy trainees who had inguinal herniorrhaphy. These individuals returned to the vigorous activity of boot training within 9 to 32 days after operation. There were no significant complications during a 10-week follow-up period. The average duration of surgical convalescence in this group was 21.9 days. It is to be noted that 2 of these patients had bilateral inguinal herniorraphies, and each patient returned to full activity 21 days after the bilateral one-stage procedures.

Should the principles of early ambulation in the early postoperative period be extended into the later phases of surgical convalescence? Is there an inconsistency at present in that many surgeons advise early ambulation and short hospital stay following common surgical procedures, and yet are loath to recommend earlier return to preoperative activity? To help answer these questions we have undertaken recently a limited study of civilian practice in the Philadelphia vicinity. One hundred patients with uncomplicated convalescence following surgical procedures of moderate frequency were studied. They were examined on one or more occasions at periodic intervals following discharge from the hospital. They were also examined at the time of return to their work and approximately three weeks later.

The operations undergone by the patients are listed in TABLE 1. The wide range of convalescent time in these uncomplicated cases for each type of surgical procedure is apparent. Not one of these patients had returned to work by the time that 75 per cent of the Air Force personnel, discussed by D. Gold in this monograph, had returned to full duty.

In order to evaluate objectively the effect on the patient of either short or relatively long total convalescence, an arbitrary scoring system was used for both subjective symptoms and objective findings. Subjective symptoms included pain, fatigue, and weakness; objective findings included infection,

Table 1

Surgical Convalescence Study

Type of procedure	No. of cases	Range (days)*
1. Appendectomy	23	15–79
2. Hemorrhoidectomy	13	21–47
3. Inguinal herniorrhaphy	16	27–67
4. Cholecystectomy	9	23–102
5. Dilatation and curettage	8	11–34
6. Hysterectomy	11	45–103
7. Salpingo-oophorectomy	8	24–90
8. Pilonidal cystectomy	7	12–41
9. Thyroidectomy	5	13–36

* Duration of "convalescence," that is, day of operation to day of return to work.

Table 2

Disability Score Versus Relative Duration of Convalescence (75 Patients)*

		←Score→			
Total number	Median time	0	1–3	4–6	7–9
		Per cent of sample			
45 Men	Before	69	12	19	0
	After	58	21	21	0
30 Women	Before	58	26	5	11
	After	54	18	18	10

* "Disability scores" are based on severity, frequency, and duration of fatigue, weakness' pain, tenderness, local infection of wound, and other far less common symptoms. Each factor was scored from zero to 3 on the basis of severity, to which was added a score of from zero to 3 on the basis of frequency and duration. A maximum score of 39 was possible. A score totaling less than 7 represents minimal symptomatology. The scores in this table are related to the median time of return to work for each operation. Those returning before the median time show essentially the same distribution of scores as those returning after the median time.

herniation, and wound tenderness. Additional significant complaints were recorded. Between 50 and 70 per cent of the patients had neither symptoms nor positive objective findings at the time of return to full activity.

Table 2 indicates that considerably more than 50 per cent of the patients felt completely well (zero score) and relatively few had even moderate disability (scores greater than 6) at the time of return to their work. The major symptom was fatigue. This was of mild to moderate severity and became more apparent with the day's activities. Symptoms of pain in the incision and associated wound tenderness, when present, were minimal.

It is possible that gradually increased activity during convalescence would have shortened the period of fatigue. Few patients receive detailed instructions from their surgeon regarding activity during convalescence

Most individuals experience increased fatigue during the first week after their return to work. This readjustment period exists apparently without relation to the length of convalescence. What is the nature of the fatigue noticed by patients? Would it have occurred if the patient had not undergone surgery, but had simply been told by an authority figure that he must "take it easy"? Would he then have had the same degree of fatigue during the period of inactivity and on return to work? Is this period comparable to a training period of athletics? Would such fatigue have occurred had the patient increased his

TABLE 3
SURGICAL CONVALESCENCE
*Physician's Forecast Versus Actual Duration**

Difference from forecast				More than 7 days	
← Within days →					
0	1–4	5–7	Total 0–7	Late	Early
Number of patients (total No. 77; 36 M, 41F)					
23	16	10	49	12	16
Percentage					
30	21	13	64	16	20

* Days from appendectomy, herniorrhaphy, or hemorrhoidectomy to day of return to work. Forecast made from 15 to 64 days (average 34, median 32) before the date forecast.

home activities even more? Is it associated with some metabolic or chemical change that we are not accustomed to measuring? These are some of the pertinent questions that still remain unanswered.

There is evidence that the physician's opinion plays a dominant role in determining the duration of *total* convalescence. TABLE 3 demonstrates the correlation of the physician's forecast of length of the convalescent period with its actual duration after appendectomy, herniorrhaphy, and hemorrhoidectomy. In this study 64 per cent of the patients returned to their jobs within 1 week of the day forecast in writing by their surgeon. This forecast time was written from 15 to 64 days —average, 34 days—prior to the predicted date of return. Therefore, the prognosis by the surgeon almost 5 weeks earlier was accurate within 1 week in 64 per cent of the cases. Thirty per cent of the patients returned on the exact day predicted by their surgeons. These results lend strong support to the hypothesis that the major factor in determining the duration of uncomplicated postsurgical convalescence is the opinion of the surgeon or physician.

It appears that the opinion of the doctor is of primary importance in establishing the duration of the convalescent period after surgery. It seems obvious from everyday experience with patients and from the studies we have reported in hypothetical cases that there is a very wide range of opinion among physicians concerning the duration of convalescence. The data presented lead us to conclude that many individuals are advised to undergo far longer convalescence than is necessary.

We believe that the data in this monograph suggest that it is physiologically and psychologically appropriate and safe to expect considerably shorter periods of surgical convalescence than is current civilian practice. As our experience with this concept enlarges, we can then better determine when convalescence really does end.

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CRITERIA FOR FITNESS AND COMMENTS ON NEGATIVE NITROGEN BALANCE

By Henry Longstreet Taylor and Ancel Keys
Laboratory of Physiological Hygiene, University of Minnesota, Minneapolis, Minn.

Since the goal of convalescence from surgery is to return the patient to his job with a normal capacity to perform the tasks that may be required of him, it is appropriate to examine convalescence as a process of recovering the capacity to perform work, which has been reduced to a variable degree by the experience of surgery. During the past fifteen years, the group at the Laboratory of Physiological Hygiene has concerned itself at periodic intervals with the effects of various biological stresses on the capacity to perform work in the broad sense. These biological situations include semistarvation, immobilization, infection, and dehydration. All of these stresses bring about nitrogen losses and are accompanied by a varying degree of loss of fitness. It is our purpose to discuss methods of studying fitness and to attempt to relate deterioration in fitness to nitrogen loss. This is intended to provide the surgeon with a yardstick by which he can judge the effect of one of the important metabolic changes due to surgery[1] on the capacity of his patient to return to work.

It is scarcely necessary to point out the difference between specific fitness to do a particular job and the more general fitness related to a wide variety of occupational situations. The performance of a trained drillpress operator in running his machine would provide the most direct measure of the fitness of such an operator. What is desired in practice[2, 3] is a scheme providing a battery of tests and measurements that will enable us to evaluate to some degree the several components of performance present in a great variety of workaday tasks and occupations. In addition, it is necessary to assess such factors as certain aspects of personality that might interfere with full utilization of capacity.

Some years ago when an attempt was made to work out a scheme to test general fitness at this laboratory, a battery of about 24 procedures[4] was put together to cover the following general areas: intellect, personality, special senses, speed, coordination, strength, and endurance.

To run through the battery once on 36 men, it was necessary to assemble a crew of 3 psychologists, 3 physiologists, a biochemist, a psychiatrist and about a dozen technicians who then worked hard for nearly 2 weeks to obtain the data necessary for the characterization of the men in a single situation. Furthermore, weeks of training the men were required to stabilize some of the tests to the point at which repetition of the test itself did not cause an improvement in score. An experiment on the effects of any agent on fitness in the broad sense is not something to be done over the week end. Clearly, there is no easy solution to the problem of fitness evaluation; today, 14 years after this tour de force was carried out on the 36 conscientious objectors who were the subjects in the Minnesota experiment on semistarvation, there has been no fundamental improvement in the field of fitness evaluation. Some tech-

TABLE 1

CONDITIONS NECESSARY FOR SUCCESSFUL FITNESS MEASUREMENT

(1) The test
    (a) Skill required for task
    (b) Effects of test repetition
    (c) Motivation
    (d) Sensitivity to stress
(2) Standardization of related variables
    (a) Time of day
    (b) Meals
    (c) Environmental temperature
    (d) Investigator
(3) Experimental design
    (a) Control period
    (b) Double-blind design
    (c) Documentation of experimental conditions

niques for the study of individual functions and components have been sharpened and improved, but apparently there is no substitute for the laborious and painstaking examination under rigidly standardized conditions of a number of the components of fitness, or of those physiological or psychological systems that can be limiting factors.

There are a great many pitfalls in the study of fitness and the factors that influence it. TABLE 1 summarizes some of the more important factors that must be kept in mind. Most fitness tests are built around a task that the subject is asked to perform. In the psychomotor area, care should be taken to devise tasks in which the components of speed, coordination, and strength can be reasonably separated. The task should be of such a nature that a rigidly standardized approach to its performance can be devised. The skill required to perform it should be understood, and a learning curve should be determined. Some tasks, such as 2-plate tapping and manipulating a dynamometer, show no change as a result of test repetition but, at the same time, they are not very sensitive to stress.[5] Measurements of coordination are at the opposite end of the scale; some of them take up to 14 trials and 2 months of time before a plateau is reached. Tests of this kind show greater sensitivity to stress than their more stable counterparts. Most psychomotor tests require a willingness on the part of the subject to do the task required of him. They are influenced to some extent by the motivation of the subject, and it is important for the investigator to provide an atmosphere of relatively constant encouragement. On the other hand, tests such as 2-plate tapping or the ball-pipe test of arm-hand speed[6] are not nearly as sensitive to motivational factors as tests of endurance, which depend on an end point of fatigue or exhaustion that is largely subjective on the part of the subject.

A good example of a test of endurance is that devised at the Harvard Fatigue Laboratory.[7] In this procedure a motor-driven treadmill is set at a grade of 8.6 per cent with the belt running at 7 mph. The subject is asked to run until he feels exhausted and the time for this is recorded. The effort put forth by the subject is assessed on the basis of his pulse rate after exercise has stopped. A fitness score is calculated that is proportional to time and inversely proportional to the pulse rate taken at specified times. In this procedure it is especially important that the investigators establish a relatively constant motivational environment.

Under section 2 in TABLE 1 it is suggested that the investigator be standardized. It is usually impossible to design a double-blind experiment in which both investigator and subject are unaware of the experimental variables. Great care must be taken not to convey to the subject the prejudices of the investigator regarding the variable under study. It is desirable and, for some functions, essential to standardize the time of day that tests are run, the relationship to meals, the order in which subjects are examined, and the environmental temperature.

A critical part of the experimental design is the control period. Inadequate documentation of the effects of test repetition during the control period is the most common fault of experimental design in studies on fitness.

FIGURE 1 illustrates this difficulty in planning experiments that provide clear-cut answers. A control group of 6 men was studied in parallel with the experimental group of 6 men who were on 580 calories of food a day. The details of this study have been partially reported elsewhere.[8, 9] The general result is an upward trend in performance, indicating that physical condition improved continuously throughout the 3 periods of control, restriction, and recovery. The conclusion is that physical conditioning took place in spite of a loss of 80 gm. of nitrogen and 7 per cent of the body weight during the experimental period. This may appear to be a satisfactory conclusion, but the fact

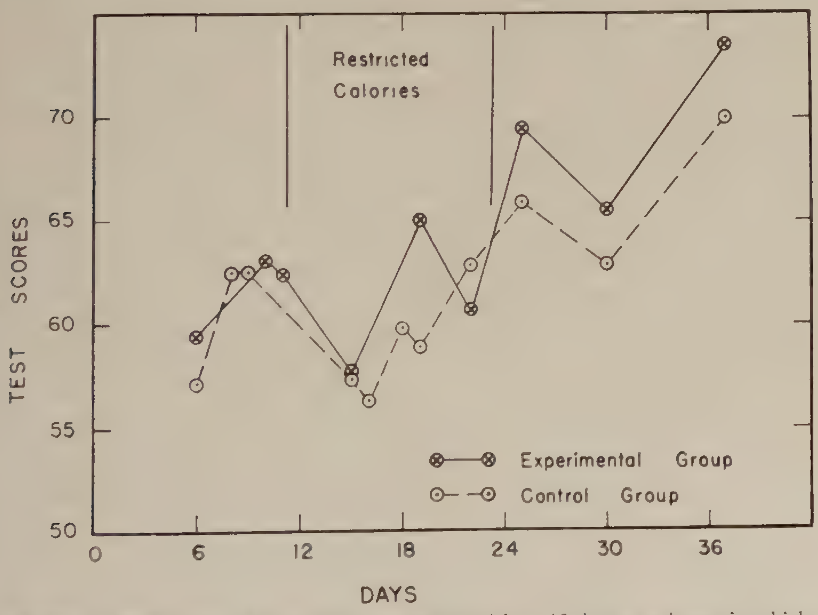

FIGURE 1. The Harvard Fitness Test scores found in a 12-day experiment in which the experimental group ate 580 calories of pure carbohydrate plus 4.5 gm. of NaCl and vitamin supplements. The control group was fed an adequate diet throughout the test period.

is that the conditioning process masked any deteriorating effects of the experimental diet.

In this experiment the control group was treated in the same manner as the experimental group, except that the diet for the former remained unchanged during the entire experiment. It was expected that the control group would demonstrate any conditioning effects produced by the daily walking on the treadmill, repetition of exhausting work for the maximal oxygen, or Harvard Fitness Tests. However, some of the usefulness of this control group was lost because the attitudes of one group apparently influenced the performance of the other. For example, the performance of the experimental group was poor on the second day of the diet period, but so was that of the control group. In a second experiment carried out the following year, 13 men were given 1000 calories daily for 24 days. The Harvard Fitness Test performance deteriorated for the first 3 days of the diet period, which leads to the conclusion that this is the usual response to a diet of this kind and that, in the experiment of the preceding year, the attitude of the experimental group was reflected in the performance of the control group.

In the past the use of such a self-determined end point test as the only criterion of fitness has led to serious errors in interpretation of the influence of stress on work capacity. Early in World War II an attempt was made to study the effects on work capacity of a sudden increase of the amount of the daily work load.[10] A field version of the Harvard Fitness Test was used to assess the fitness of the subjects for work, and a marked deterioration was found during the first three days. A re-examination of the problem failed to confirm the results of the first investigations,[11] which appeared to be due to a change in the attitude of the subjects in the first investigation toward the amount of work they were willing to do.

The Harvard Fitness Test gives useful information regarding the way capacity can be modified by motivation. Information on capacity that is independent of motivation can be obtained by studying one of the important limiting factors in severe muscular work, that is, the maximal oxygen intake.[12, 13] The maximal oxygen intake is measured under specified conditions, and other conditions may produce somewhat different values. The subject is asked to run for 3 minutes at 7 miles an hour on the motor-driven treadmill. The work of Robinson[14] has demonstrated that under these conditions the oxygen intake reaches a steady state in 90 seconds. At the Laboratory of Physiological Hygiene, the expired air is collected from 1 min. 45 sec. to 2 min. 45 sec. after the start of exercise. The oxygen intake is calculated from the volume and composition of this gas sample. FIGURE 2 demonstrates what happens when tests of this kind are repeated with an increase of 2.5 per cent in the grade for each test. Clearly, there is a point beyond which a further increase in external work does not evoke an increase in oxygen intake. When the increase in grade no longer produces an increase in O_2 intake, the subject is moving as much oxygen to the working muscles as it is possible for his respiratory cardiovascular system to manage. Any additional work done depends on anaerobic energy-producing mechanisms that result in the accumulation of oxygen debt. The attainment of the maximal oxygen intake can be proved by the demon-

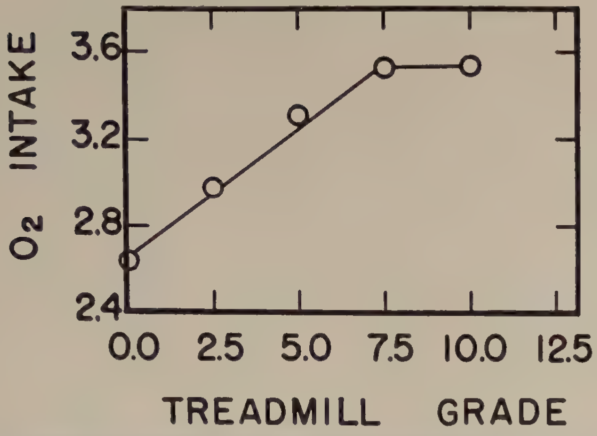

FIGURE 2. The effect of increasing the grade of the treadmill on the oxygen consumption, expressed as liters per minute, of a 20-year-old male during the third minute of a 3-minute run at 7 mph. Each point represents a separate 3-minute run.

stration of an oxygen intake plateau with increasing work load, and this is independent of motivation and skill. One might speculate that in a debilitated state the subject—no matter how willing—would not be able to push himself to the limit of his cardiovascular system. At the end of the semistarvation experiment in 1945,[4] however, when the men had lost 24 per cent of their body weight, we were able to demonstrate an oxygen intake plateau in 10 of the 12 men studied.

Now that some problems and techniques have been examined, it may be useful to look for a moment at the larger picture. The above-mentioned list of areas related to over-all performance includes intellective capacity. Various facets of this function were examined in 2 stress situations: 6 months of semistarvation,[4, 15] and mild thiamine restriction followed by acute thiamine deficiency.[16] Intellective capacity proved to be very resistant to stress. Those changes noted were small and were related to the speed with which mental manipulations were made. The special senses were also found to be resistant to nutritional stress.[4] TABLE 2 gives the pattern of performance deterioration found after exposing young men to 4 stress situations: 6 months of semistarvation, which produced a 24 per cent loss of weight;[4] an acute thiamine deficiency in which 12 young men ate a thiamine-free diet for 23 days;[16, 17] 3 weeks of bed rest;[18] and acute starvation (water ad libitum) accompanied by hard work for 5 days.[5, 19] The general areas of performance examined were the speeds of 3 different muscle groups, coordination (2 measures), strength (grip strength and back strength), endurance measured by the Harvard Fitness Test time and maximal oxygen intake and, finally, skill in and pulse rate response to grade walking on a motor-driven treadmill.

TABLE 2 shows that the pattern of deterioration is quite different in the several situations. This is as it should be, because different physiological systems bear the principal brunt of each of the different stresses. Some of these deteriorations can be predicted a priori, but we should add that such

TABLE 2

FITNESS DETERIORATION IN SELECTED STRESSES*

Function	Semistarvation	Thiamine deficiency	Bed rest	Acute starvation
Speed				
hand	+			+++
arms and hands	+	+		++
body and arms	+	+++		+++
Coordination				
number	++	+++		+
time	+	+++		+
Strength				
grip	+++			
back	+++			
Endurance				
time	+++	+	+++	+++
max. O_2	+++		+++	
Walking				
skill				+
pulse			+++	+++

* + = slight; ++ = moderate; +++ = marked.

predictions have not always been borne out, notably in the thiamine deficiency, where it seemed safe to predict that endurance, or walking pulse, or both, would be affected.

The adjustment to upright posture has been used as a criterion of fitness[20] and has been mentioned elsewhere in this monograph. In general, when cardiovascular deterioration has resulted from exposure to a stress situation, the finding in tilt-table tests has been parallel to the pulse rate response to low-level steady-state work.[18, 21] In the semistarvation situation,[22] the adjustment of the cardiovascular system to tilting at 70° for 15 min. was very good. This was true in spite of the fact that the men had periods in which they felt weak and occasionally fainted. In selecting the procedures to use in studying deconditioning and its recovery in specific situations, great care must be used, and more than one procedure is essential unless the stress being studied is well understood.

The pulse rate response to a standard task has been for many years the cornerstone of much fitness testing. Grade walking on the treadmill is an ideal task, not only because efficiency in walking is highly constant in most adults, but also because the oxygen consumption, that is, the metabolic load imposed on the physiological system, can be predicted from the weight of a man and the speed and grade of the treadmill almost as well as it can be measured.[23] Alterations in the response of physiological variables such as pulse rate, then, will be due to superimposed experimental variables and not to improvements in skill in walking. Note, however, that in two of the stress situations we have studied no change in pulse rate was observed. The very widespread conviction of people employing fitness tests based on pulse rates that any stress sufficiently severe to impair performance will result in a high pulse rate during work is a persistent and pernicious oversimplification.

Consideration of the results of the Minnesota experiment on semistarvation leads to the specific problem of the effects of nitrogen loss. The experience in the Minnesota experiment on semistarvation demonstrated that the largest losses in performance capacity occurred in strength and endurance, and we base our remarks regarding the problem of nitrogen loss on the results obtained using the maximal oxygen intake and the grip strength as our indices of fitness.

In the Minnesota experiment on semistarvation,[4] 32 men receiving an average of 1570 calories daily for 6 months maintained a mode of life during the control period that required roughly 3200 calories for nitrogen equilibrium. This regimen resulted in a 24 per cent weight loss and a total nitrogen loss of between 900 and 450 gm. Observations on fitness were made at 3 months and at 6 months during the period of diet restriction. After 3 months of semistarvation the men lost an average of 17.5 per cent of their body weight and 325 gm. of nitrogen. Marked deterioration in maximal oxygen intake, Harvard Fitness Test score, and strength had occurred. The exact time at which fitness deterioration began was not determined.

In 1952 the Quartermaster Corps of the United States Army asked the Laboratory of Physiological Hygiene to determine how long physical fitness was maintained when men were living on emergency, or "survival," rations. The laboratory then carried out four experiments, data from three of which is discussed below. The important experimental conditions are presented in TABLE 3. Some of the details have been reported elsewhere.[8, 9, 24] The subjects were military personnel confined to a suite of air-conditioned rooms in the laboratory. During the experimental periods, they received a daily ration of 1000 calories of pure carbohydrate, 4.5 grams of NaCl, and supplements of the water-soluble vitamins, and they did 1200 to 1400 calories of work a day on the motor-driven treadmill. Thirteen men completed the regimen, receiving water ad libitum. Six men were given 1800 cc. of water a day for 10 days, and 6 men received only 900 cc. of water a day for 5 days. In both cases 1000 calories of carbohydrate were fed through the sixteenth day. TABLE 3 shows that the water restrictions with the resulting dehydration had a marked effect on the nitrogen loss. The men who had only 900 cc. of water per day lost 50 grams of nitrogen more than those on water ad libitum. Unpublished studies of the urinary excretion of the 17-hydroxycorticosteroids by R. Huseby, Department of Surgical Research, University of Colorado, Denver, Colo., revealed that this excessive loss of nitrogen was accompanied by an increase in adrenal activity. There seems little reason to doubt that the excessive excretion of nitrogen observed in the dehydration experiments is analogous to the excessive nitrogen loss that occurs during the catabolic phase after surgery.

TABLE 4 presents a summary for 7 stress situations of the degree of nitrogen loss and the extent of the loss of fitness as measured by the maximal oxygen intake and the approximate time of recovery of fitness. This table shows that over a wide range of nitrogen loss, up to a total of approximately 150 gm., the loss of fitness is independent of nitrogen loss. Furthermore, significant amounts of nitrogen (150 grams) may be lost without seriously interfering with fitness or with the time necessary for recovery. The exact amount of nitrogen

TABLE 3

CUMULATIVE NITROGEN EXCRETION*

Experiment	No. of subjects	Daily water intake	Initial body weight (kg.)	Cumulative nitrogen excretion (gm.) M	S.D.
54	13	ad lib.	69.10	89.2	±14.7
55A	6	1800 cc.	73.01	115.0	±21.4
55B	6	900 cc.	75.43	141.7	±20.4

* The cumulative nitrogen excretion—urine plus sweat—of normal men in good physical condition while subsisting on a daily diet of 1000 calories of pure carbohydrate, 4.5 gm. of NaCl, and vitamin supplements, with water supplied as indicated. The cumulative nitrogen excretion is given for 16 days for all 3 experiments.

TABLE 4

COMPARATIVE NITROGEN LOSSES*

Conditions	Duration	Activity during stress	Cumulative N loss	% loss max. O_2	Recovery time
Semistarvation[4]	6 months	work	400–450 gm.	26	3–6 months
Semistarvation[4]	3 months	work	320 gm.	18	no observations
Semistarvation[8, 9]	24 days	work	135 gm.	0.0	5–10 days
Semistarvation[24]	16 days	work	115 gm.	0.0	5–10 days
Water, 1800 cc./day	10 days	work			
Semistarvation[24]	16 days	work	141 gm.	0.0	5–10 days
Water, 900 cc./day	5 days	work			
Acute starvation[19]	5 days	work	45 gm.	0.0	48 hours
Bed rest[18]	3 weeks	—	37 gm.	15	3–5 weeks
Malaria[21]	7–12 days	—	100–150 gm.†	16	4–6 weeks

* A comparison of nitrogen losses under a variety of conditions, with the loss of fitness as measured by the percentage of decline in the maximal oxygen intake per kilo of body weight and the time necessary to recover pre-experimental fitness by this and other measures.

† Estimated from data of Howard *et al.*[25]

loss that will produce an unequivocal loss of fitness is not known, but it must lie between 150 and 320 gm.

Inactivity produces a definite deterioration of the performance of the cardiovascular system and seriously hampers endurance. The weak feeling that patients have on first arising is very probably related to poor cardiovascular adjustment. In the great majority of cases it is not related to "strength." Strength as used in this paper is roughly equivalent to the maximum force that can be produced momentarily under isometric conditions.

Acute starvation with work had very marked effects on performance, which were mostly referable to low blood-sugar concentration, dehydration, and mild acidosis. These were quickly repaired upon return to a normal diet.

The malaria experiment[21] is a useful reference point in this series. Twelve men were infected with the McCoy strain of the *Plasmodium vivax* and allowed to develop 5 to 8 chills. The extent of the nitrogen loss is estimated from the data of Howard *et al.*[25] This experiment represents the combined effects of inactivity, a moderately large nitroged loss, and the miscellaneous toxic factors associated with the disease. The degree of fitness deterioration and the recovery time suggest that when these factors are combined no synergistic effect is present. This is good evidence that the use of a routine of daily prescribed work during nutritional experiments is a valid method of reducing the number of variables studied at one time.

Some comment should be made regarding the site of loss of nitrogen. It is frequently claimed that the nitrogen is lost almost exclusively from the muscles. In the presence of extensive nitrogen loss, such a concept is not only incorrect, but it can be dangerous if therapy is planned on this basis. The heart shares in the nitrogen loss and loses weight and volume in almost the same proportion as the skeletal musculature.[26, 27] It has been pointed out that overloading the circulation in this situation may lead to congestive heart failure.[28] There is every reason to believe that the liver loses considerable protein in the presence of a negative nitrogen balance. The fasting animal loses 40 per cent of its liver protein in the first 7 days.[29] If metabolism is held at a high level, signs of liver damage will appear in the otherwise healthy young man after 5 days of fasting.[30]

On the other hand, there is every reason to believe that, if the patient is supplied with minimal amounts of carbohydrates, the liver will be adequately protected, and that an individual who is not originally overweight must lose about 20 per cent of his weight before his cardiac musculature has been sufficiently damaged to be a cause of concern.

The data presented here are consistent with the thesis put forward by Whipple[31] some years ago, that the well-nourished individual has a mobile pool of proteins available in an emergency for a variety of purposes. However, there is no reason for putting great emphasis on the precise figure of 150 gm. of nitrogen as a measure of the size of this pool, since the yardstick used here, that is, fitness measurements, is not sufficiently precise. It is altogether conceivable that a substantial amount of nitrogen might be lost from all tissues before a measurable decline in performance could be detected.

Several people studying metabolic response to stress, such as surgery, have asked whether the catabolic nitrogen loss in the presence of surgery, infectious disease, and other stresses is helpful or harmful. It is difficult to find ways to answer this question that do not involve teleological reasoning. Fitness measurements provide a crude yardstick that, in terms of convalescence, have some meaning. On the other hand, damage to some organs at the cellular level may be overlooked when the only consideration is the capacity to perform exhausting work.

Our results are strictly limited to young men in good physical condition who are well motivated. Direct application of the nitrogen loss figures presented here to the management of middle-aged males in the United States in poor physical condition who are convalescing from extensive surgery is hazardous. There can be little doubt, however, that the middle-aged United States male can tolerate a substantial nitrogen loss. When one inspects the reported figures for nitrogen loss after surgery[1, 32, 33] and realizes that nitrogen losses of 50 gm. or less are the rule, and that losses of more than 100 gm. are rare, it seems reasonable to infer that catabolic nitrogen loss after surgery will seldom interfere seriously with rehabilitation. This inference is especially appropriate if the surgeon follows the kind of common-sense dietary treatment that has been so clearly presented to him,[1] and that is consistent with the sound nutritional principles recently elaborated.[34]

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CONVALESCENCE, REHABILITATION, AND THE THERAPEUTIC USE OF STRESS

By Howard A. Rusk

Department of Physical Medicine and Rehabilitation, New York University-Bellevue Medical Center, New York, N. Y.

It is paradoxical that war brings mankind certain benefits. That through a concerted effort to annihilate man we have learned more and better ways to preserve him is a sorry fact, but nevertheless true. The science of medicine has passed through many phases, and disasters of one sort or another have accounted for many of its advances.

One such disaster was World War II, and from it we have begun to learn, among other things, the importance of rehabilitation in the successful treatment of mental and physical diseases. This means no more than that we have begun to deal with the influence of disease upon the individual in terms of its economic, vocational, social, and personal effects. In our search for new drugs, diagnostic procedures, surgical techniques, and laboratory methods, we have overlooked too frequently the extraphysical results of illness—the changes it creates in the mind and in the habits of the patient as well as in his body.

During a hospital stay the average patient suffers 10 per cent of the time from pain and 90 per cent of the time from boredom. This is equally true in both civilian and military hospitals. However, it is more devastating in the latter, for there is less time to waste in war than in peace. The realization that wasted time could be converted into purposeful activity by a well-integrated rehabilitation program, with equal emphasis on physical reconditioning, psychological readjustment, and avocational training, led to the establishment of special convalescent hospitals by the United States Army Air Force in 1943. These hospitals treated men, not diseases. Their purpose was to provide the combat soldier with a laboratory of opportunity where he might regain not only health but the attitudes, habits, and values compatible with the normal behavior patterns that war had disrupted and distorted.

The hospital staff was enlarged to include not only medical specialists, but physical therapists, educators, athletic trainers, occupational therapists, social service workers, personal counselors, and vocational guidance experts who worked as a team to treat the needs of the "whole man." The captain of the team was the personal physician or "family doctor" to whom each patient was assigned on entering the hospital, and to whom he could go with any problem, no matter what its nature.

With the aid of this highly qualified and diversified hospital staff, a broad program of rehabilitation was put into operation, with the result that the hospital was transformed into a combination schoolroom, gymnasium, machine shop, psychiatric clinic, vocational guidance center, and town hall.

Physical reconditioning was begun the moment acute illness or surgery terminated and, through a progressive and graduated program of calisthenics, active recreation, and competitive team play, patients were able to reach the peak of physical fitness during the convalescent period.

Some of the pertinent observations made on the results of the Convalescent Training Program after three years of experience were that: hospitalization time was shortened, hospital readmissions were reduced, sick leaves were eliminated except in extraordinary cases, and the morale of the soldier-patients was immeasurably improved when they were kept busy and interested in purposeful activity.

A number of intersting clinical studies were made. A. C. Van Ravenswaay[1] studied 645 cases of virus pneumonia treated in the same "acute" ward. These cases were later assigned to alternate convalescent wards. In Ward I nature was allowed to take its course, so to speak, and men sat around until they themselves and the medical officer felt they were ready for duty. In Ward II the patients were kept in bed until their sedimentation rates reached 10 mm. in one half hour, and then were started on a reconditioning program, beginning with exercise for one half hour the first day and increasing progressively until the twelfth day, when the patient was participating in a full 5-hour day of physical training, mass games, competitive sports, and active recreation, including a 10-mile hike. Group I averaged 45 days' hospitalization with a 30 per cent recurrence rate. The patients in Group II averaged only 31 days with but a 3 per cent recurrence rate.

Peter Karpovich[2] studied a similar group of two hundred aviation cadets convalescing from virus pneumonia at the School of Aviation Medicine, San Antonio, Texas. Using a modification of the Harvard Step Test and starting as early as the first afebrile day, Karpovich found that, by the reactions to this test, it was possible to determine, with some degree of accuracy, the patient's ability to participate in an active convalescent program. An interesting by-product of Karpovich's work was the observation that patients undergoing the tests required five days' less hospitalization time than those participating in the general program. These findings suggest that the convalescent may be able to participate in an even more active program with beneficial results.

Early in the operation of the convalescent program it was noted clinically that orthopedic patients requiring fixation of a specific member, if kept in top physical condition generally, did not show the usual degree of muscular atrophy in the fixed part and, when the cast was removed, could be reconditioned to duty in approximately one half the usual convalescent time. Whether this was due to increased blood velocity, exercise within the cast, vasomotor stimulation, or lack of capillary loss is a question that demands further investigation.

As a part of the United States Army Air Force Rheumatic Fever Control Program, Karpovich and others carried out a study on the testing of physical fitness and the physical training of convalescent rheumatic fever patients.[3] Because of the chronic, recurrent nature of the disease and the possibility of disabling cardiac sequelae, it was felt that special emphasis should be placed on the standardization of physical activity and convalescent training of these patients. This was done by working out a series of graduated physical fitness tests that could be used, in conjunction with the usual clinical observations, to determine the rate at which the patient could safely be permitted to progress to increased physical activity. The details of this study are available in the original report; it is interesting to note that there were no recurrences or untoward reactions in any patient participating in the study.

Reports on the effects of bed rest have been detailed in the literature,[4-7] and special studies have been made by Ancel Keys, University of Minnesota Medical School, Minneapolis, Minn. (personal communication), and David Barr.[8] Reports on the effects of early ambulation in surgical patients have been made by John H. Powers,[9] Allan Whipple,[10] and many others, and their significant observations are most pertinent in evaluating the management of convalescence. More recent data on the effects of early ambulation are reported elsewhere in this monograph by David Gold and John H. Powers.

Early in 1945, it was recognized by the Baruch Committee on Physical Medicine, New York, N. Y., that much had been learned in the rehabilitation programs of the Armed Forces that would be of value in the care of physically and emotionally disabled civilians. A subcommittee on civilian rehabilitation centers was appointed to work out a simple basic blueprint that would translate war rehabilitation experience into its civilian applications.[11]

In 1950 the Committee on Public Health Relations of the New York Academy of Medicine, New York, N. Y., issued a report on convalescence prepared by a special subcommittee,[12] which pointed out that up to that time convalescent care had never been more than a minor phase of the provision made by the city of New York for the medical care of the sick and injured who are its charges. The report indicated that, although nearly half of the hospital beds there, are in municipal institutions, the city had never built or operated a convalescent hospital.

During these intervening eight years, many advances have been made in definitive medical and surgical care and in rehabilitation. In general, however, this report's classification of convalescent institutions remains valid. It pointed out that the master plans for hospital and related facilities in New York, which were prepared by the Hospital Council of Greater New York, had defined the time of convalescent care as beginning "early after the acute phase of illness or injury" and continuing "until complete recovery or rehabilitation has been attained." The plan recommended that one fourth of hospital beds (one bed per thousand of the population), in the city should be devoted to convalescence and rehabilitation.

In this same 1950 report, the committee classified convalescent institutions and care as: rest homes, general convalescent hospitals, rehabilitation centers, and home care. The validity of this estimate of the needs for convalescent and rehabilitation beds, which was made eight years ago, has been verified in subsequent studies and has led to development of the "Homestead" program of the New York City Department of Hospitals, which was officially launched in March, 1958. The Homestead program is a new concept concerning care of the chronically disabled based on the recognition that those patients usually called chronically ill and disabled are in reality two distinct groups of patients with different problems and different needs.[13]

The chronically ill are patients who require regular and continuing medical services of the type best provided only within a hospital. The chronically disabled, on the other hand, are those with permanent and often static disabilities who require medical and hospital services only occasionally. These latter patients, since they do not need as much care as actively ill patients, receive less attention in hospitals and inevitably feel neglected and rejected. The very nature of a hospital whose primary mission is to provide definitive care to the actively ill means that the basic needs of the chronically disabled—affection, emotional security, spiritual development, social contacts, opportunities for self-expression through creative activity, and the assurance of being regarded as an individual—often go unmet due to pressure on the staff to provide acute care first. Over and above this, the chronically disabled in hospitals are forced to live for months or years in an environment in which pain and suffereing are a part of the daily routine.

To lessen the cost of the care of the chronically disabled and also to provide an environment and program more suited to their needs, the New York City Department of Hospitals is currently converting a number of wings of hospitals no longer needed for acute care into Homesteads, or public home infirmary beds. In these Homesteads emphasis is placed on the recreational, rehabilitative, social, and emotional needs of the chronically disabled residents, and only the necessary minimal medical and nursing services are provided. An important economic factor in this program is the more than 50 per cent reimbursement through the state and federal governments for this care, which costs about $8.50 per patient per day in contrast to $25.00 a day in the facilities of an acute general hospital.

The first Homestead, dedicated in March 1958, is a part of Goldwater Memorial Hospital, where a 90-bed unit has been in operation since August, 1957. This is now being expanded to 360 beds. It is expected that by late 1958 or early 1959 a total of 3500 Homestead beds will have been activated within the system of the New York City Department of Hospitals, which has more than 20,000 beds.

Development of the Homestead concept goes back to 1953. At that time, through a special grant of the New York Foundation, New York, N. Y., a geriatrics rehabilitation service was started at Goldwater Memorial Hospital as a joint project of the New York University-Bellevue Medical Center and the New York City Department of Hospitals.

Eli Ginzberg of the Department of Economics, Columbia University, New York, N. Y., had previously reported: "The municipal hospitals of the City of New York are overcrowded because they are unable to transfer chronic patients to other suitable facilities. This situation obtains even in Goldwater Memorial Hospital, which was established (1939) as a specialized hospital for the active treatment of patients with long-term illness but whose patient population has become increasingly composed of individuals requiring custodial care. . . ."[14]

Ginzberg's conclusions were substantiated by a study in 1954,[15] which showed that of 95 unselected custodial patients at Goldwater Memorial Hospital whose average age was 68.5 years, only 7 were felt to be in need of continued hospitalization, and 2 of these were considered questionable.

As a result of these findings another study, again financed by the New York Foundation, was undertaken to obtain a city-wide sampling of patients in municipal hospitals. This report,[16] issued in 1956, stated that 1 of every 5 patients in the city's municipal general and chronic disease hospitals was there, not because he needed hospital services, but simply because he had no other place to go.

These patients suffered primarily from neurological conditions, cardiovascular diseases, and arthritis. After completion of their intensive medical care and rehabilitation, they were still greatly restricted in activity. Some had no homes or relatives, and others were too disabled to return to a home environment. The combination of age and physical disability had brought these patients to a state of medical indigency that compelled their admission to city hospitals.

The results of the 1956 report have been further confirmed by a personal communication regarding another study recently conducted by the New York State Division of Housing, the purpose of which was to determine the feasibility of requirements for a housing program that would meet home-care needs of the aged. The immediate and continued care required by patients more than 65 years of age were surveyed on a typical day in 3 New York municipal and 3 New York voluntary hospitals. The conclusion is that 1 of every 5 patients over 65 in these hospitals could be discharged if adequate institutional or home facilities and services were available. The finding is identical with that of the Hospital Patient Survey.[16]

The concept of the Homestead program is an extension of the changes in our basic philosophy regarding convalescence and rehabilitation that have developed over the past fifteen years. These changed concepts are based primarily on our increased ability to evaluate the functional capacities of patients physically, emotionally, socially, and vocationally, and then to develop realistic programs to meet their needs.

However, whether it be in wound healing or in recreational activities for the aged, the common factor of beneficent stress is present. In all these programs the passive concept of "convalescence" is being replaced by the more modern concept of dynamic, active rehabilitation built around not only the medical, but also the emotional, social, and vocational needs of the patient.

To the surgeon, stress has always implied strain. In some instances stress with that connotation is to be avoided because of its physiological effects on the surgical procedure. In other instances, and for the same reason, it is to be encouraged. In his over-all consideration of the patient, however, the surgeon must think of beneficent stress as a therapeutic aid—as the adaptation and stimulation that culminates in the fulfillment of the goals and ambitions of the patient, which are the expression of his personality.

Man's achievement of his goals is intimately related to the stress point: if he does not use his full potential, he vegetates; if he goes from stress to strain, he breaks. When he is able either by himself or with proper guidance to find the perfect pitch or end point of his personal stress, his life can be a fully satisfactory and rewarding one.

It has recently been shown in a careful study of 250 patients with an average age of 63 who have had strokes of apoplexy that the severity of the stroke had no correlation with the success of rehabilitation. If the patient had work to do, a home to which he could go, and someone to love and who loved him, the results were good, regardless of the severity of the disability. Certainly this can be said of patients in surgical convalescence. The desire to live rather than to be merely alive is essential to the physical, emotional, and endocrinological factors so important in immunological and anabolic victories over degenerative processes.

In simple terms, it is the will to live, to work, and to contribute that make for successful convalescence.

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SOCIOLOGICAL IMPORTANCE OF THE CONVALESCENT PERIOD

By Paul R. Hawley
American College of Surgeons, Chicago, Ill.

The sociological importance of any element in our social structure depends on both the impact of individual occurrences and the frequency with which they happen. Unfortunately there are neither comprehensive nor wholly reliable data upon which precise measurements with respect to these two questions for the convalescent period can be made. We can only draw a few broad inferences from some unrelated studies.

We may begin with the altogether obvious observation that the period of convalescence exerts an adverse effect upon both the individual and society when it is either too short or too long. In the first instance, it may result in diminished efficiency or a further period of disability and, in the second, in economic waste and a change for the worse in the psychology of the patient.

The factor of economic waste affects not only the individual but also society. So, too, does the factor of the psychology, or perhaps better, the philosophy of workers. Space does not permit a discussion of all the effects of prolonged convalescence, and this paper is limited to the mention of a few of the more important effects upon society as a whole.

First, how many people are exposed each year to convalescence from surgery? Dickinson and Raymond[1] have estimated that in 1954 approximately 8,100,000 persons, male and female, underwent surgery—excluding uncomplicated obstetrics—in the hospitals of the United States. This tells us very little about the impact upon society, since about 13.5 per cent of these operations were tonsillectomies, the great majority in young children and, among the remainder, were an unknown number of unemployed females. However, even if only one half of these surgical operations involved employed persons, it would mean 4,000,000 people, which is not an insignificant number: when unemployment because of business depression passes this figure, the nation is concerned.

The Research Council for Economic Security has published a study of prolonged absences from work due to nonoccupational disabilities in the years from 1953 through 1956.[2] The study included 145 different groups representing a total of 193,856 man-years of employment. Only absences of greater than 4 weeks' duration were included in the published data. This limitation should not detract from the value of this study when applied to convalescence from surgery, since absences from work of less than 4 weeks following surgery has been shown by Moss *et al.*[3] to be of rather infrequent occurrence.

In the Research Council's study, the rate of occurrence of prolonged absence following surgery was 32 per 1000 man-years of exposure. This means that in a group of 1000 workers there would be 32 yearly absences due to surgery.

However, this crude rate tells us very little, for the rate for all males was 12.5 per 1000 man-years of exposure, and that for females, 22.2. The first solid fact we learn, then, is that almost twice as many employed females as employed males are exposed to surgery each year.

This is of sociological importance, but it is not entirely new information;

industry has long known that absenteeism is far higher among females. It may be new information, however, that surgery contributes heavily to this difference.

Nor do these rates tell the whole story, since they are corrected only for sex. Age exerts an even greater influence on absenteeism in both sexes, ranging from 5.5 to 42.4 years for all males, and from 6.5 to 61.0 years for all females. Excluding those who are 65 and older, among whom the rate is highest in both sexes, the rate for males rises rather slowly up to 55 years of age, where it is 26.3, and thereafter it rises more rapidly. The curve is quite different for females. It rises sharply to 35 years of age and then remains relatively flat until the advanced age of 65. Up to 55 years of age, the rate for females is more than double that of males.

Here, then, is the first suggestion of an important sociological effect. The advisability of retiring workers at the age of 60 or 65 is now being questioned. The fact that workers between 55 and 64 years of age are absent because of surgical illness 4 times as often as those between 25 and 34 and twice as often as those between 35 and 44 will not encourage employers to keep older workers on the payroll.

Before drawing any inferences, we must know the duration as well as the incidence of absences. Here the differences are so slight as to be of little significance. The average for both sexes is about 10 weeks. Curiously, while duration of stay in hospital increases with age, the duration of absences from surgical illness increases only slightly in the older groups. It is the frequency of illness that increases absenteeism as age advances.

Here we begin to tread on dangerous ground; and I admit frankly that I place no great reliance upon the application of these data to those published by Dickinson and Raymond.[1] However, merely to suggest how great a problem surgical convalescence can be, and to be ultraconservative in our estimate, let us assume that of the 8,100 000 surgical operations reported by Dickinson, 3,000,000 were undergone by employed males and 2,000,000 by employed females. On this assumption, there would be a total loss of 50,000,000 weeks of labor per year. At an average take-home pay of $80.00 per week—a conservative estimate, since management as well as labor is included in the figure—this represents a loss in dollars of 4,000,000,000, which is by no means an inconsiderable sum, even in these days of astronomical figures. The fact that any part of these absences are covered by sick-leave pay or by loss of income insurance does not reduce the loss. It is still a loss to someone or to some institution.

Obviously, this loss cannot be prevented entirely, nor can it be reduced to a very low figure. However, diasability due to surgery of an average of 10 weeks does seem excessive in this day and age, and the studies by Moss and Dohan indicate that it is elevated considerably by widely different practices among different groups and different doctors, as well as in different areas. If this average could be reduced by 25 per cent, which seems a reasonable possibility, there might be an annual saving of $1,000,000,000.

In this connection, consider again the rather surprising fact that the duration of surgical convalescence as measured by absence from work increases very little as age advances. It is well known that recovery from surgery is slower among older people. Hospital records show their stay in hospital to be longer; yet they return to work as soon as do the younger people. This raises the question of motivation. Are older people more fearful of losing their jobs, or more reluctant to seek others? Since many companies refuse to hire as new employees persons over 40 years of age, this would seem to be a factor. Moreover, since the younger person recovers more rapidly from surgery, it would seem that he could return to work far sooner than the older person, if he were similarly motivated.

Thus far we have been dealing with averages, and averages do not tell the full story. Data on disability insurance paid during convalescence from several kinds of illness and a study of the duration of hospitalization in the same illnesses* are very enlightening on this question. They confirm the inference from the data already presented that there is only a very slight increase in average hospital stay and in absence from work as age advances. However, the really significant fact this information demonstrates is the wide deviation from the average—a deviation of more than 100 per cent above the average and almost as much below. In other words, this is a problem of individuals, not of averages. Of course, cases with complications or with certain sequelae convalesce more slowly than do uncomplicated cases; but complications and sequelae do not occur with sufficient frequency to account for such wide variations.

The disability insurance data demonstrate another very significant fact: deviations from the average among persons 40 or more years of age are, for the most part, not only considerably fewer, but also they are weighted on the side of shorter rather than longer convalescence. This supports our previous speculation that, other factors being equal, older workers tend to return to work sooner than the younger. For example, in herniorrhaphy in employed males, the average stay in hospital at 50 years of age was one third longer than at 20; yet the average duration of convalescence in the older group was only about 10 per cent greater.

These data suggest very strongly that this problem must be attacked in individual cases, rather than in the mass, and that such saving as may be made will be effected by reduction in the periods of convalescence of that segment which, for some reason or other, greatly exceeds the average. That this may be possible is indicated by the almost equal number of deviations below the average.

Where, then, would a saving be made? Perhaps most of it would accrue to the affected individuals and their families. On the other hand, a large part would today show as a reduction of losses for companies carrying disability insurance; in turn, this saving would be passed on to those paying the premiums for such insuracne. It should also have some slight effect on the cost of goods produced, since absenteeism is known to add to the cost of production.

The idea that security programs could have any ill effects is very unpopular in this country. Nevertheless, from an objective point of view, all insurance of this kind invites abuses. Health and disability insurance are the only forms of insurance that are not, and cannot easily be, protected by law against abuses. How long could fire insurance exist if arson were not a crime?

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* I am indebted to the John Hancock Mutual Life Insurance Co., Boston, Mass., for information on disability insurance and to the Professional Activities Study of the Commission on Professional and Hospital Activities, Inc., Ann Arbor, Mich., for information on the duration of hospitalization in certain illnesses.

The greatest motivating need of man has always been, and always will be, security—security both for today and in the future with respect to food, shelter, and clothing. Man can obtain security in only two ways: by his own efforts, or through a community of effort whereby he shares in the products of the efforts of others. When he can obtain his needs—even on a minimal scale—from sources other than his own efforts, his incentive to work is reduced, if not destroyed. This affects different individuals to different degrees; however, only a prejudiced person would contend that it is not a recognizable influence in our society today.

One sociological effect of prolonged surgical convalescence is to increase the cost of insurance against loss of income. This increase must be passed on to all who are insured, since insurance carriers cannot pay out more than they receive. This, in turn, reduces the amount of money available for the purchase of the products of labor. Insurance premiums, as distinguished from insurance benefits, pay for few services and purchase even fewer goods. In the last analysis, they purchase unproductivity. They are essential expenditures when need exists, but they become wasted resources when the benefits they provide are abused.

To summarize, convalescence from surgery can never be eliminated. Illness represents only waste, both to the individual and to society. As an inseparable part of illness, convalescence is waste—except that, properly limited, it minimizes any further waste. When extended beyond the point of profitable return, it is both an extravagance and a destroyer of incentive. These facts make it of great sociological importance.

In the inadequate studies that have been made, there is some suggestion that motivation of the patient is an important factor in determining the duration of convalescence. The greater the stake a person has in his job, the sooner he returns to work after surgery.

I think our data are sufficiently reliable for the conclusion that this is a problem of individuals. There is indication that, among properly motivated individuals, convalsecence has already been reduced to surprisingly short periods. How much the physician influences the duration of convalescence is indicated in the study by Moss *et al.*, but here again it is a problem of individual physicians.

Conferences of the kind that have resulted in this monograph should alert the medical profession to the problem and persuade ultraconservative physicians to modify their practices. Nevertheless, it is doubtful whether all the education in the world would have much effect on the patient who enjoys a compensated convalescence more than a paid job.

Although we shall have convalescence as long as we have illness, it is of great importance to society that it not be extended until its evils outweigh its benefits.

The point of maximum benefiit, which will always vary with individual cases, can be determined only by further careful studies.

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THE IMPORTANCE OF CONVALESCENCE AND REHABILITATION TO NATIONAL MANPOWER

By Frank B. Berry
Assistant Secretary of Defense (Health and Medical), Washington, D. C.

Some years ago Clarence Morgenthau wrote:

"A reconsideration of the problem of social action must start with a recognition of the fundamental distinction which exists between social problems and those with which the natural sciences deal. The latter are either solvable at a particular moment of history or they are not. When they are solved, they are solved once and for all. Social problems . . . are of a different type.

"The problem of world peace, for instance, in counter-distinction to the problem of the air cooled engine, is not closer to solution today than it was when it first presented itself to the human mind. More books have been written and more intellectual energy has been spent on the problem of international peace during the last 100 years than in all previous history."[1]

Now, to quote from the Hoover Commission Task Force on Federal Medical Services of August 1955, which applies more specifically to our discussion today:

"More than half of the nation's hospital beds are devoted to care of the mentally ill and this year alone some 250,000 patients will have their first admission to mental hospitals. A number of these individuals will be young, many of them of superior intelligence and some destined for chronic illness and a prolonged hospital stay. At our present rate of illness one out of every 12 children born will spend some time in a mental hospital. Mental patients constitute the largest group of Federal and State patients and modest estimates place the cost of mental disease to the taxpayer at about one billion dollars per year. The number of patients in these institutions is increasing steadily at the rate of approximately 10,000 per year, and when we speak of the number of patients receiving care in mental hospitals, well over 700,000 persons; this is only one measure of the incidence of mental disease and emotional disturbance in the United States. This figure does not include the number of people suffering from mental disorders who are kept at home or who are in sanatoria, nursing homes and general hospitals, and thus not included in the psychiatric hospital statistics. Our most serious bottleneck in the provision of proper care of the mentally ill is the lack of trained personnel, physicians, nurses and other auxiliary workers. Although this situation has improved somewhat in recent years, shortages of trained personnel continue not only to hamper efforts to improve general conditions, but also to restrict efforts to discover new methods of treatment and even to prevent the wide application of new therapeutic procedures. More research is needed and yet we have too few professionally qualified people in this branch of research. As the population and our life span increase, the problem will grow and as the problem grows, costs will become greater, hence it is obvious that some answer must be found."[2]

Notwithstanding this gloomy outlook, considerable progress has been made. Paresis and organic diseases of the brain due to syphilis have ceased to be the sizable problems that they were a decade ago. Formerly 10 per cent of all individuals who acquired syphilis became victims of paresis but, due to new therapeutic measures, this figure has dropped to less than 3 per cent. Schizophrenia, a common type of mental disease, formerly had a recovery rate of only 15 to 20 per cent, whereas today this figure has jumped to 40 to 60 per cent, and so also with other mental diseases, under the influence of new drugs and new forms of therapy.

During the latter part of Herbert Hoover's and the earlier years of Franklin D. Roosevelt's terms of office, White House conferences were held on convalescent care and later on child care. At these meetings the subject of this monograph was discussed, except that convalescent care under the impetus of World War II has been further developed into rehabilitation, under the constructive leadership of Howard Rusk. This concept began largely with the rehabilitation of those who had suffered major or permanent disability from wounds, but has now been developed with extraordinary success into a most effective program for the chronically ill and the aged, such as, for example, those who have suffered cerebral damage ("strokes"), or who have considered themselves bedridden heart cases.

Quite apart from the permanently disabled first mentioned, why has rehabilitation come so much to the fore in recent years? It seems to me that this is directly connected with increased longevity and with political change, disease, morbidity, and mortality. The acute infectious diseases take their greatest toll in the early years of life, and pneumonia, typhoid, and tuberculosis add appreciably to the mortality of those in late adolescence and early adult life. When ill, young people with their tremendous reserve, fresh tissues, and a normal growth potential tend to recover. They have life before them, the desire to get back into it, and every other stimulus to complete recovery.

Conversely, through the normal processes of aging, an increasingly large proportion of our population is composed of those older in years and also a group of adults of lesser physical resistance who might otherwise have succumbed to infection in early life; hence, something more than mere convalescence is needed. An active program is necessary to reawaken the stimulus to live and return to work. It is easy to prolong convalescence, become dependent upon and enjoy the sympathy of others, and grow introspective. Therefore our modern programs of active rehabilitation have been sought as an answer to these problems. Not many years ago these older people were condemned to chronic invalidism for the rest of their lives, such as those who "had a stroke" with the resulting paralysis of one side and loss of speech. There was often some recovery of speech, but as a rule no effort was made to re-educate the muscles of their paralyzed limbs. The result was that they became burdens on their families for their remaining years. Today, due to a better grasp of the value of and benefits derived from rehabilitation, this need not happen.

There is a concept, as true for illness as it is for injury, that the moment either occurs convalescence and rehabilitation should begin. Sometimes, of course, the battle is lost and the patient dies, but in the vast majority of instances he recovers. He must not simply recover, however; rather, it is the duty of the medical profession and the family to see to it that he recovers to the maximum. Therefore, the more of those who are sick or injured we can rehabilitate to self-help, the more people we shall release for needed duties in the home, in industry, or in any walk of life.

A good illustration is the patient cited at a recent New York Academy of Medicine "Graduate Fortnight" by a district nurse working in the poorer districts of Manhattan, who reported the rehabilitation of a woman of 75 with a heart condition who had been bedridden for three months. This woman lived with her daughter in a small apartment and required not only financial support but also bedside care. This seemed to be a hopeless situation but, under a proper regimen of care and sympathetic conversations with the patient and the daughter, and in cooperation with the doctor, immediate improvement resulted, with the consequence that by the end of the first month the woman was sitting on the side of her bed and, by the end of the eighth month, she was up and about helping in the care of the apartment and looking forward to attending the wedding of her niece. There is nothing magical about this episode nor was any special treatment required—merely the good medical care of a general practitioner, the tact, encouragement, and controlled sympathy of the district nurse who visited only one or two hours each day, and the wise advice and encouragement given to the patient and her daughter.

When muscle retraining is necessary, as after paralysis, fractures, or severe injury, certain special care and treatment, as well as physical therapy, are necessary and should commence at the earliest possible time. By such treatment, the period of convalescence immediately becomes one of rehabilitation. "Convalescence" is derived from the Latin word *convalescentia* and means the time between the subsidence of an illness and the return to health. To rehabilitate is from *rehabilitare*, to restore to a status of independent earning power. All of us know how convalescence may readily be prolonged by fear or desire on the part of the patient and his relatives, and overcautiousness and lack of attention or interest on the part of the physician. Rehabilitation, by its very connotation, is a more imaginative word and implies return to health and strength.

In World War II the United States Army was handicapped by a unit intended to be helpful, the Convalescent Hospital, a field army unit of 3000 beds to which convalescents from the divisions and evacuation hospitals were sent until they were able to return to duty. This was an assignment nobody wanted: commanding officers didn't want it; the doctors hated it; the corpsmen found it dull; and the patients had nothing to do. The result was that in the Seventh Army an experiment was instituted that paid big dividends. The convalescent hospital was broken into small units, each attached to an evacuation hospital. Each unit was under the command of a convalescing line officer and under the medical supervision of the staff of the evacuation hospital. Thus, these small units were far easier to handle than the larger, cumbersome 3000-bed unit, which was usually far in the rear, without transportation and almost forgotten. Men did not lose their identity as soldiers;

they were constantly subject to military discipline; they reported to the hospital for dressings or therapy as needed; and, when able, took part in progressive drills and physical conditioning excerises. In this manner many troops were saved from evacuation out of the Army area and restored to their own units.

"National security is not a purely military matter but includes economic and political factors."[3]

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PSYCHOLOGICAL FACTORS IN SURGICAL CONVALESCENCE

By Arthur M. Sutherland
Memorial Center for Cancer and Allied Diseases and Department of Clinical Medicine, Cornell University Medical School, New York, N.Y.

We are all well acquainted with the patient who should have completely recovered from his surgical experience and yet continues to limit his activities and amplify his complaints far beyond our ability to explain and, sometimes, to tolerate. We are also well aware that psychological factors may be as responsible for this situation as cryptic infections or the classic sponge left in the wound. The group at the Memorial Center, of which I am a member, as well as others[1-8] have attempted to identify some of those factors that prolong convalescence and lead to protracted invalidism. Although severe problems of psychogenic invalidism in response to surgery are, fortunately, the exception rather than the rule, the same factors probably operate to some extent in a far larger number of patients. Very often these factors express themselves in ways that escape the notice of the physician or surgeon, or lead him to misinterpret their significance.

What signals the end of convalescence? It is extremely difficult to put arbitrary limits on a continuum and, except for legal purposes, it is not very useful. However, for our own guidance in dealing with the individual patient, we must make a judgment as to when he has recovered. Therefore, we have chosen as the termination of convalescence or invalidism that point in time at which the patient has resumed his valued preoperative activities. This appears to be a fairly obvious choice, but of necessity different activities are not resumed at a uniform rate. For example, an individual may resume full-time work, yet severely limit his recreational and his sexual activity, or he may resume his recreational activities to a greater degree than his work, which is more common. He may appear to be working, but actually be investing considerably less energy in his job, or he may, if the exigencies demand it, put in a full day's work despite considerable fear that he is damaging his body.

At times, some activities are sacrificed permanently. After hysterectomy a woman may cease intercourse altogether, on the grounds that she is too delicate or that the parts are too delicate for such an activity.[5] When this happens, can one say that she has "recovered" from the effects of surgery?

So vast are the permutations and combinations of resumed levels of activities, that we have found any broad judgment based on one prominent criterion such as resumption of work to be misleading. For this reason we make careful surveys of the preoperative and postoperative activities of our patients, particularly in the areas of work, and of recreational, social, and sexual function. Comparison of these activities before and after surgery gives a far more accurate idea of the impact of surgery on the patient. Just as the physical therapist makes a most careful survey of the power of individual muscles and functions, so must those who are interested in the patient's general adjustment carefully survey how well he can flex and move his psychological muscles and joints. The therapeutic implication is obvious. We can then turn our attention to those functions or activities that are needlessly restricted. The physical therapist does not content himself with merely mobilizing a joint; he aims at restoring the function of the member to as nearly normal as possible, and we should not be content with less.

Actions speak louder than words—what the patient actually does is far more revealing than his testimony as to how he feels. His actions, as with those of any other human being, are intimately connected with his beliefs about and perceptions of the world—or the environment, as it is more elegantly called—as well as his own body. These beliefs and perceptions are the determinants of actions in his work, play, and marital and family life. When they are erroneous, especially in regard to his body and his physiology, they are prime causes of psychological invalidism. Those therapists who can read and understand the language of behavior can readily penetrate to the underlying beliefs.[9]

A man's acts or behavior may be foolish, unwise, or self-defeating, but they are not without purpose. When, after surgery, a patient unnecessarily restricts activities, often valued ones, such restriction is purposeful. It serves an end.[10]

We hear a great deal about "secondary gain," that is, the use of the illness itself to coerce and manipulate the environment, to get something, usually called "attention," or to avoid something, traditionally, work. This undoubtedly occurs but, in our experience, it is both rare and vastly overemphasized. The secondary gains rarely compensate for the primary losses, even when the patient is attempting to make them do precisely that. The demand for "attention" is usually a demand for reassurance on the part of a badly frightened person who is, basically, sufficiently healthy to accept reassurance from others. If the reassurance is given concerning what really frightens the patient, the demand for attention lessens or disappears. Of course, an individual may try to utilize an illness to avoid unpleasant situations, but this also is protective in that the patient tries to avoid situations perceived as either dangerous or fraught with humiliating failure. The problem revolves about the question why that situation is so perceived, not about why the patient uses his illness to escape it.

To repeat, except in certain culturally determined situations, secondary gain as a motive for invalidism is rare. When deeply valued life activities are sacrificed because of invalidism, secondary gain plays no role or, at best, a very minor one.

The primary if not the sole purpose of restricting valued activities is the avoidance of further injury and the promotion of the process of repair. It is not to avoid unwanted duties or responsibilities, or to gain some advantage. On the contrary, the patient is very much aware of the real sacrifices he is making and the losses he is sustaining. He sees them as the price he must pay for physical integrity and even survival. It is the goal of psychological rehabilitation to demonstrate that such sacrifices are not necessary, and that the resumption of valued life activity is not merely compatible with health, but conducive to it.

What is the source of the patient's notions about his physical state and what he must do or sacrifice to preserve it? The obvious answer is from both within and without; although these sources cannot always be separated, they can be identified for our purposes. The interior sources are the patient's unconscious, plus his thoughts about what has happened to him. The exterior sources are largely medical personnel and the patient's social or ethnic background.[11]

In certain individuals who seem greatly preoccupied with self-destructive tendencies and whose patterns of adaptation have included masochistic self-punishment or inhibition of activities for fantasied sins, serious hypochondriacal reactions may occur. As a rule, these individuals approach surgery with a very likely expectation of serious injury and, in the postoperative phase, this expectation becomes converted into the belief that irreparable damage has taken place. It is frequently associated with the belief that there is a total quantity of energy in the body that is intimately connected with its parts, and that the subtraction of any part of the body must necessarily diminish that energy or vital force. This is especially true of sexual or sexualized organs. Consequently, as the result of extensive surgery, such patients believe their vital energy to be diminished, regardless of their true physiological condition; therefore, they believe themselves unable to be active with whatever freedom they have had in the past. They also believe that the lack of energy renders them more vulnerable to other diseases. As a result, they regularly restrict work, recreation, and sexual activity, and regard such restrictions as necessary for the maintenance of even basal health. Such a restriction of activities can be seen easily as a lifesaving maneuver: "I treat my body life a soft-boiled egg, liable to break its shell at any minute," a patient may say, or, "I have lost confidence in my body."

The hypochondriacal response accounts for much economic deterioration. Closely allied to this response, and often interwoven with it, are the patient's notions about the effect of the surgery, or organ loss or alteration, on his general physiological functioning. Some of these notions are apparently old cultural ideas, some with quite a respectable ancestry. The idea that food is converted directly to semen appears in Aristotle and is probably older. Another venerated idea is that menstruation is an excretory process ridding the body of poison, and the loss of the uterus means that these poisons are dammed up within the body.

Some notions appear idiosyncratic. Each individual has his own private cosmology of which private physiological theories are an integral part. When an organ is removed, altered, or even surgically repaired, many implicit assumptions or vague ideas are made explicit. These assumptions are not unconscious, although unconscious beliefs undoubtedly help shape or select them; they are merely unformulated until the surgical event requires that they be dealt with in the conscious philosophy. These misshapen, mistaken, and erroneous private physiological tenets are doubly important. They may be so taken for granted and appear so obvious to the patient that they are never mentioned. The physician may be unaware of their existence unless he probes for them. Surprised as the physician may be at these ideas, he is no less surprised than the patient at the doctor's ignorance of these "eternal verities." Moreover, they form the basis for action that leads to restriction of activities or to bizarre and self-defeating patterns. Pelvic or rectal surgery affords the best examples of such notions. The uterus may be regarded as the source of woman's strength and ability to do her housework; hence its loss is thought to deprive her of the major energy-generating organ.[8] It is sometimes seen as the source of her sexual desire and responsiveness; therefore, without it she can no longer respond. The uterus is also thought to be the source of her femininity, or of her ability to attract men, without which she has no sex appeal. This idea is reminiscent of the Eighteenth and Nineteenth Century notion of "chemical affinities" as an explanation of sexual attraction. The male analogue was held by a highly sophisticated gentleman, a beau of the old school, who expressed amazement that women should still find him attractive in purely social situations after he had undergone castration for carcinoma of the prostate.

To many colostomy patients[6] irrigation presents a threat because it may wash out the nourishment, the "upper stomach," or the strength. Conversely, incomplete evacuations may be thought to cause obstruction and death.

The rituals of eating in relation to irrigation of the colostomy preoccupy many such patients. Before irrigation, patients may eat to strengthen the body, or refrain from eating in order not to tax the digestive apparatus. Often, they eat to replenish, or because now there is room, or they fast to rest the bowels. The notion that all fecal matter must be evacuated to avoid poisoning is a source of much worry and concern, which leads at times to irrigating practices that seriously handicap the patient.

One must patiently seek out these ideas and refute them. Once they have become well established and the patient's life structured on them, he is somewhat reluctant to abandon them and try unknown ways that seem dangerous. It is undoubtedly best to inform the patient of the truth either preoperatively or immediately postoperatively, rather than to wait until his own notions have developed into determinants of action.

Postoperative complications such as phlebothrombosis, a wound infection, or dehiscence can also reinforce beliefs in body fragility, thereby prolonging convalescence. Somatic echos of psychic tension and anxiety, such as palpitations, muscle-tension phenomena, or loss of appetite, add their not inconsiderable load.

Depression from whatever cause or of whatever variety is a potent prolonger of convalescence and source of invalidism, as well as a high hurdle to the return to previous activities. The usual surgical patient is, fortunately, not clinically depressed; if he is, it is a concurrent illness. However, those patients whose surgery is another step in a long, protracted, and threatening or potentially incapacitating illness may well be depressed. Moreover, patients whose surgery results in a serious change in body form and function become depressed as they contemplate the disruption of lifelong patterns of adaptations to the world and their own needs, which adaptations involve the body part or organ now sacrificed. The compulsive man or woman for whom "cleanliness is next to godliness," or the converse, may be very depressed by a colostomy. The woman whose self-respect and expectation of respect from others is based on physical beauty may have a very difficult time after mastectomy.

Some depression is to be expected after surgery that subtracts a valued part or organ. It usually lifts when the patient finds himself acceptable to his family and friends and able to resume valued life activities. However, when the lost part or organ has played a key part in the lifelong adaptation, such as the rectal sphincter in the compulsive, or the breast in the narcissistic, feelings of self-hatred and unacceptability to others may result in very severe depressions.

For any depressed person, work, or social, or marital activities, are very difficult.[12] His attention span is short, his concentration powers poor, his irritability, especially with himself, is great. Moreover, for a postoperative patient who is significantly depressed, inability to function well may compound his belief that he is permanently disfigured and can never resume his old life. No significantly depressed patient, postoperative or otherwise, should be forced to assume the strains of everyday life as a form of occupational therapy. Whoever urges such a course is guilty of circular thinking, confusing ends with means.

If the sense of unacceptability to self and others is strong, or the believed need of concealment is great, patients may tend to lead very circumscribed, almost eremitic, lives. When circumstances force them into contact with others, such patients are anxious, and they tend to avoid others as much as possible. They may seek jobs requiring as little contact with others as possible, and they restrict social events to the immediate family, or television, which is even worse.

Depression and withdrawal can be so severe as to warrant psychiatric intervention and even hospitalization. Fortunately, most postoperative depressions are mild and self-limited. They can be shortened by good relations with the doctor, as well as with friends and family.

The question is often asked whether neurotics are more prone to prolonged convalescence than are normal patients. Since, for want of a better definition, normal patients are defined in this context as those who have short convalescences, the answer must be affirmative. It seems fairer to say that, if the illness, surgery, or organ or part loss activates old neurotic conflicts, then prolonged convalescence may result, but not always. In fact, very short convalescences are possible. An individual who must believe himself to be invulnerable, or one whose anxieties are inflamed by the very sight of doctors or hospitals, will probably leave at the earliest opportunity. So, too, will the pathologically independent patient who is unable to trust others, or the compulsively active person who is fearful of being condemned or forgotten if he fails to work or to serve others. These patients are no less neurotic than the chronic complainers. Their neuroses are simply expressed in a more socially acceptable form—one that is far more convenient for us.

As a matter of fact, a concomitant psychosis does not necessarily prolong convalescence. A somatic illness, surgery, and recovery usually remain peripheral to the psychotic patient's train of thought. Consequently, convalescence proceeds on schedule.

It is not a patient's neurosis that determines whether convalescence is prolonged or psychogenic invalidism results. Rehabilitation is delayed or incomplete when the illness, the surgery, or serious changes in body form and function subsequent to surgery either disrupt or threaten to disrupt strategic adaptations.

Because of the subtleties of these patterns and the scope and force of human adaptive powers, and because of the unpredictability of events in the patient's future, prediction as to the length or ease of convalescence or rehabilitation is very difficult, at least for us. Underestimating the patient's own resources, we have usually erred on the side of gloom. When we have felt reasonably certain that the projected surgery did not disrupt a prime method of adaptation, however, we have usually been right. Nevertheless, in our interviews, which are designed to furnish material for predictions, we have achieved something more.[13] We have explored the patient's feelings, his fears, and his misconceptions, and allowed him to relate to us in a positive way. We could not forego correcting his misconceptions and allaying his anxieties. Most of our patients were referred to us as "bad psychological risks." However, one or two preoperative interviews, ostensibly fact-finding in purpose, were sufficiently therapeutic to effect smooth convalescence in the majority of cases.

The implication of this result is obvious, and it reinforces what we have believed for some time. The investment of a small amount of professional time preoperatively in helping the patient to discard misconceptions, in allaying his fears, and in discussing future convalescent plans, pays enormous dividends postoperatively. The rapport that this preoperative investment creates remains an asset forever.

At times, both private and clinic patients complain bitterly that they can never talk to the doctor: "All you are is a chart"; "They bounce off the walls"; "They ought to bank the turns"; "By the time I open my mouth, he's gone." It is true that the surgeon has less time than almost anyone for small talk, but the patient does not want to chitchat. Rather, he wants information to use as a guide for immediate and future action. Without that information the patient is very uneasy and usually errs on the safe side, unnecessarily restricting himself.

Doctors often believe themselves to be giving such information, although their directives are so vague or ill-defined as to force decisions upon the patient himself: "Don't do too much"; "Don't overdo"; "Don't lift anything too heavy"; "Take it easy." The patient is left to decide what is too much or too heavy and how "easy," and to wonder what will happen if he does too much or lifts something too heavy. To avoid the disasters attendant on "too much," the patient usually does too little. He needs to know what to expect, and he should have more specific instructions about his own regimen.

The medical director of a national company has observed that time away from work for convalescence after one type of operation is twice as long in one part of the country as it is in another. This implies that there are fashions in convalescence, which can only mean inadequate knowledge in this field. To be on the safe side, the doctor himself may prolong a patient's convalescence. Occasionally and, we hope, rarely, although we have known instances of it the doctor projects his own hypochondria into the situation, keeping the patient fearful and partially invalided

In contrast, a doctor's refusal to accept the patient's real limitations is equally damaging. It creates guilt and anxiety, and provides grounds for believing that the doctor lacks skill. The doctor's attitude seems to arise from a belief that all patients want to be invalids, and a fear of their dependence, especially if it should devolve upon himself.

The demands of dependence, which are often treated somewhat moralistically as "regressive," are usually maneuvers to enlist powerful figures, professional and otherwise, by an individual who feels threatened and unable to defend himself, or perhaps even incapable of fulfilling his own basic needs. Early convalescence evokes considerable realistic dependence. If the demands arising from this realistic emotional and physical dependence are inadequately met, excessive anxiety may be generated and the patient may be convinced, either that nobody can help him, or that he is not worthy of help. Dependence does not persist as a serious symptom in the vast majority of patients; as they test out the environment and are able to resume valued patterns or establish new patterns of behavior, it disappears.

As we know, the patient's family does much to modify his response to illness and surgery.[14] This complex subject can only be mentioned here. However, it should be noted that family members may require more attention than the patient, to forestall a projection upon the patient of their own private physiological views, which could result in further distortions of the truth and in the imposition of even greater limitations on the patient.

Family tensions often complicate convalescence and rehabilitation. In the main, if family relationships have been good, they continue to be so and are an asset to the patient. If they have been indifferent or poor, they usually dereriorate under the impact of serious illness or surgery and a necessarily long convalescence. Deterioration in family relationships may intensify the patient's guilt, anxiety, and depression, as well as his sense of unacceptability.

A short interview with an observant member of the family can frequently provide far more accurate information about his attitudes and behavior than extensive interviews with the patient himself. The patient may find it necessary, for various reasons, to present a distorted picture of his state. A relative's or wife's statements may show that he is far more or far less invalided than he himself would lead the doctor to believe.

In addition to the psychological barriers to rehabilitation, there are certain other barriers, or modifiers; these can be called cultural.[15-18] The aim of most rehabilitation programs is to restore the patient to gainful or socially useful activity, and by this means to help him regain and maintain his self-respect. We have found, however, that not all patients share our own conceptions of what activities are necessary for maintaining self-respect or for preserving status. Values are not only personal; they are also derived from an individual's ethnic group and social class. In certain groups, for example, work has by no means the importance that it has for those who have been raised in the Puritan tradition. In such groups sickness, past or present, is regarded as a perfectly valid excuse for not working, or for devoting one's energies to noneconomic and, hence, less taxing pursuits. There is no loss of status. In fact, a family may feel disgraced if an older man continues to work when his children could support him. In another group sickness confers a special status on women whereby they acquire the right to coercive control over husbands and children. This status is surrendered only reluctantly, and may result in the pretense of invalidism where none in reality exists. No valued life activities are lost, but another, that of controlling the family, is strengthened and extended.

In our enthusiasm for rehabilitation we should not attempt to impose personal values derived from our own ethnic group and social class on those for whom they may be inappropriate.

After any illness the average patient cautiously tests out his powers until he is sure than he can resume all his previous activities without danger. Certain cases may require the specialized help of the physical therapist and the psychiatrist. For the large majority of patients, however, the surgeon is the first choice for assistance. When there is a good relationship and easy communication between surgeon and patient, the surgeon knowledgeable in physical medicine and in the human understanding called psychology or psychiatry will materially shorten convalescence. He will easily guide the patient to the resumption of all his valued life activities, which the surgeon's skill has now made possible.

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A STUDY OF THE COMPLICATIONS OF THE POSTHOSPITALIZATION PERIOD OF SURGICAL CONVALESCENCE

By Kenneth G. Bartels and Charles G. Johnston

Department of Surgery, Wayne State University College of Medicine, Detroit Receiving Hospital, Detroit, and Dearborn Veterans Administration Hospital, Dearborn, Mich.

The optimum time for postoperative patients to leave the hospital and return to partial or full activity has been of some concern to us for many years. The process of wound healing has been didactically impressed upon us as a serial process, a biological procedure that follows strict time schedules. It is therefore easy to understand the customary fixing of the time of activity for postoperative patients within narrow limits and the reason for relating this to the biological schedules of wound healing.

Our first concern about this problem arose in 1937, when we were working in an overcrowded city hospital from which it seemed urgent to release patients as soon as possible. When there was someone to care for them at home, they were discharged as soon as they could be transported by car. They were told to take things easy and notify us immediately if they had any difficulties. We were astonished that patients who were allowed to decide about activity for themselves usually had cogent reasons for getting about early. We were surprised that most individuals who seemed to have important social activities to carry on were usually not only in good physical condition, but also quite active by the time they returned about a week later to have their wounds checked. Actually, we did not stress the release of patients at an unreasonably early date; rather, we indicated that patients could go home as soon as they were able to do at home what they could do in the hospital.

Obviously, there are two problems to consider in relation to the time when a patient leaves the hospital: his physiological condition, and the state of his wound. In elective procedures where there have been no gross alterations of visceral function, the primary problem is that of wound healing. In order to limit our study to the simple problem of the wound and its healing in relation to return to activity, we attempted to carry out a study of the reaction of patients who had undergone herniorrhaphy. Cases such as appendectomy, exploratory laporotomy, and cholecystectomy might offer other examples of operative procedures that could have been included in this investigation.

We began our evaluation with a review of the charts of all patients who had inguinal herniorraphies performed at the Detroit Receiving Hospital in 1956. There were 194 patients who had 197 hospital admissions for 206 herniorraphies. Their ages ranged from 4 weeks to 87 years; 22 were females, and 172 were males. Of the cases operated upon, 39 were done as emergencies for incarceration. There were 4 postoperative deaths, all occurring in the emergency group.

To determine the length of postoperative hospitalization, the patients were divided into 3 groups: those with no complications, those who developed a postoperative complication, and those detained in the hospital for other rea-

TABLE 1

POSTOPERATIVE HOSPITALIZATION IN DAYS

Age	No. complication			Complication*			Held for other reasons	
	No. of patients	Av. stay	Range	No. of patients	Av. stay	Range	No. of patients	Av. stay
0–9	32	2.5	(1–5)	2	7.0	(2–12)	3	15.3
10–19	5	3.2	(1–6)				1	6.0
20–29	12	3.1	(2–5)					
30–39	17	3.4	(2–5)				1	5.0
40–49	22	4.4	(2–7)	1	7.0	(7)	1	7.0
50–59	31	4.6	(3–7)	2	6.5	(5–8)		
60–69	30	5.0	(1–8)	1	7.0	(7)	1	8.0
70–79	24	5.2	(2–10)	3	6.7	(2–11)	1	13.0
80–89	2	5.0	(4–6)	1	4.0	(4)		
Total	175	4.1		10	6.5		8	10.6

* The patients who expired are not included in this table.

sons. These data are shown in TABLE 1. The reasons for additional hospitalization were: evaluation of congenital lesions, 3; further study of chronic problems, 3; psychosis, 1; and other surgery, 1.

The patients who developed complications following surgery were placed in 1 of 2 groups, depending on whether the complication occured before or after their release from the hospital. These groups will be referred to as the postoperative and posthospitalization groups, respectively. Only those patients were included whose cases had been followed for at least 10 days. There were 131 such cases. The postoperative complications are shown in TABLE 2 and the posthospitalization complications in TABLE 3. Two of the patients in the latter group were rehospitalized for treatment of their complications; all others were adequately managed on an outpatient basis.

TABLE 2

POSTOPERATIVE COMPLICATIONS

Wound complications		Other complications	
Wound infection	2	Ileal gangrene with perforation	1*
Local cellulitis	2	Myocardial infarction	1*
Wound hematoma	1	Acute congestive failure	1*
Wound seroma	3	Hepatic failure	1*
		Pneumonitis	1
		Hematemesis	1
Total	8 (6.1%)	Total	6 (4.6%)

* Died.

TABLE 3

POSTHOSPITALIZATION COMPLICATIONS

Wound infection	3
Local cellulitis	1
Stitch abscess	2
Thrombophlebitis	2
Total	8

We sought to extend our investigation of the posthospitalization period by means of mailed questionnaires. Several significant difficulties caused us to abandon this method. The response was poor and the form was unsatisfactorily or incompletely filled out in a number of cases. Patients were reluctant to answer for fear of jeopardizing their welfare status, compensation claims, disability pensions, job privileges, or similar factors. Some feared that this investigation was related to their capacity to pay their hospital bills.

Moreover, the case material of the Detroit Receiving Hospital was not entirely suited to our needs. A large percentage of the patients come from indigent and welfare groups; the majority are not regularly employed; many do not return to the outpatient department for follow-up care and study; and a large number have no permanent address. We did include those we could study adequately, but the fact that we were able to communicate personally with only 17 attests to our difficulty in utilizing this group.

A few patients were interviewed after they had completed the questionnaire. It was readily apparent that a precise picture of a patient's activity in the posthospitalization period and on the job could be obtained only by interviewing the patient personally. In this manner patients could be reassured that no ulterior motives existed, points of confusion could be clarified, and detailed information could be elicited more accurately.

For these reasons we adopted the interview technique. Each patient was given a copy of the questionnaire to study; he was then interviewed and the questionnaire was filled out by the interrogator. All patients were questioned in complete privacy by the same individual, and each patient was examined at the conclusion of the interview. The patients were assured that all information was confidential and would not become a part of their medical record. The questionnaire employed is illustrated in TABLE 4. Sufficient space, which is not shown here, was provided to permit elaboration of all data. The questionnaire was designed to serve as an outline for the interview, and not of itself to constitute the interview.

To obtain a more representative cross section, 3 groups of unselected herniorrhaphy patients were studied: 54 private cases, 53 cases from a Veterans Administration Hospital, and 17 cases from a city hospital. These 3 groups are designated as P, V.A., and C, respectively, throughout this study. The patients, all males, ranged in age from 16 to 80, and in social status from indigents to executives.

Postoperative hospitalization for the three groups is shown in TABLE 5. We were interested to find that none of these patients felt he had gone home from the hospital too soon. A few patients thought they could have gone home sooner. The vast majority felt that their release was "just right," probably reflecting the lay philosophy that the "doctor knows best." A few patients requested delay in their release because the house was being painted, the family was out of town for the week end, no one could call for them, or for other similar reasons. We had all these patients get out of bed on the day of surgery. Postoperative complications are shown in TABLE 6 and posthospitalization complications in TABLE 7. Of the patients who developed posthospitalization complications, none required readmission.

TABLE 4

QUESTIONNAIRE

Name____________ Age____ Sex M. F. White Colored
Operation____________ Hospital____________ Date____________
Do you think your stay in the hospital after your operation was too long______ too short______ neither______ Why____
Did your doctor explain to you what was done in the operation?____________
Did you have any trouble in the area of your operation after you left the hospital? Describe.
Any other difficulty?____________ Describe occupation____________
When did you return to work?______ Full duty______ Light duty______
Why did you return to work when you did?____________
Do you think you might have returned to work earlier?______ Later______
Did the fact that you had an operation handicap you at work?______ How______
What did you do between the time you left the hospital and the time you returned to work? (Indicate time in each instance)
Rest in bed
Walking about neighborhood
Sat in chair (reading, watching television, etc.)
Walking about house
Walking up stairs. How many?
Describe forms of exercise and/or recreation and indicate when.
Working about house
Working in yard or garden
Swimming
Gymnasium work, calisthenics, exercise
Bowling
Hunting and fishing
Driving or riding in car
Golf
Sexual activity
Handball or tennis
Baseball
Hobby
Others. Name
Did any of the above cause you discomfort? How?
Approximately what is the heaviest weight you lifted the first week? Second week? Third week?
Do you think that the time you spent after operation with little to do made you feel weaker than normal? Stronger?
Do you feel that when you returned to work, the extra rest made it difficult to perform your usual assigned duties? Yes No
Did you gain strength faster on the job? Resting at home?
If you had another similar operation, what would you do differently?
Length of stay in hospital
Activity at home?
Length of time off the job
Job restrictions
Do you have any other illness or disability that affects your activity?
Physical examination____________

TABLE 5

POSTOPERATIVE HOSPITALIZATION IN DAYS

	No complication		Complication		No. held
Group	No.	Av. stay	No.	Av. stay	Other surgery
P	50	4.9	4	15.8	
V.A.	47	7.0	3	15.7	3
C	15	5.6	1	14.0	1
Total	112	5.9	8	15.5	4

TABLE 6

POSTOPERATIVE COMPLICATIONS

Complication	Group P	V.A.	C
Wound infection		2	
Pneumonitis	1		1
Thrombophlebitis	1		
Urinary retention	1		
Drug reaction		1	
Myocardial infarct	1		

TABLE 7

POSTHOSPITALIZATION COMPLICATIONS

Complication	Group P	V.A.	C
Wound infection		1	
Stitch abscess	1	1	
Testicular pain	1	1	
Back and leg pain	1	1	
Testicular atrophy	1		
Sclerosis of arm vein	1		

Although we do not believe that the convalescent period necessarily extends to the day the patient resumes his normal occupation, we were interested in determining when these patients returned to work and the nature of their work. All but 2 of the 54 private cases were employed, whereas 32 of the 53 V.A. cases and 5 of the 17 city hospital cases had jobs. Job titles were of little help in classifying the jobs, nor was it possible to establish precise, quantitative job criteria. After completing all interviews and recording the details of each occupation, we studied these data and made a job classification.

In general, the jobs fell into four classes: (1) sedentary, with little standing or walking and no significant lifting; (2) primarily standing and walking, with some sitting and lifting; (3) moderate exertion involving repeated manipulation of weights up to about 40 lb., occasional climbing, or digging; and (4) heavy exertion, with repeated lifting of over 50 lb. Some patients were given "light duty," rather than their usual work, for varying periods of time following their return. The results of this portion of the study are shown in TABLE 8 which makes it evident that there is little correlation between the rigors of a man's occupation and the time he returns to work.

We were interested in determining what effect the patient's financial relationship to his job had on the time of his return to work; that is, whether the self-employed man behaved differently than the employee. Our data on this question are shown in TABLE 9. As one might expect, there was a significant difference in the time of return to work between these two groups; the self-employed individual returned far sooner than the employee. Furthermore, this difference was even greater than the difference in time of return to work between the groups having the easiest and the most strenuous jobs, as shown in TABLE 8.

TABLE 8

RETURN TO WORK*

Job Class.	P		V.A.		C		Total	
	No.	Av. range	No.	Av. range	No.	Av. range	No.	Av. range
1	8	14.8 (6–56)	10	32.7 (5–63)			18	24.7 (5–63)
2	19	30.5 (14–70)	5	19.6 (7–28)	1	49.0 (49)	25	29.1 (7–70)
3	12	27.0 (7–70)	10	43.4 (21–84)	2	24.5 (21–28)	24	33.6 (7–84)
4	13	36.5 (16–63)	7	29.0 (14–42)	2	34.0 (12–56)	22	33.9 (12–63)
Total	52	28.8	32	36.2	5	33.2	89	30.6

* All ranges and averages are in postoperative days.

TABLE 9

RETURN TO WORK*

Job	P		V.A.		C		Total	
	No.	Av. range	No.	Av. range	No.	Av. range	No.	Av. range
Group I†	17	17.5 (7–56)	6	21.0 (7–42)			23	18.4 (7–56)
Group II‡	35	34.3 (6–70)	26	39.8 (5–84)	5	33.2 (12–56)	66	36.4 (5–84)
Total	52	28.8	32	36.2	5	33.2	89	30.6

* All ranges and averages are in postoperative days.

† Group I includes the self-employed or executive patients.

‡ Group II includes patients who are employees.

Some patients are prohibited from returning to work before a specified interval by the industrial physician, the family doctor, or the operating surgeon. Other patients are advised that they may return as soon as they desire and are encouraged to do so at an early date. Still other patients, although told when they should return, go earlier than advised for reasons of finance or boredom. Another group will take whatever sick time, annual leave, or vacation time they have accumulated, then return to work. Those with seasonal employment usually have their surgery done during the lay-off period, and their return to work is determined by the demands of their jobs. We regarded the return to work in the first group of patients described above as having been determined by a physician and, in the other groups, by the patient himself. Our results are given in TABLE 10. We found that those patients who were permitted to return to work when they felt able lost only half as much time from the job as those whose return was governed by a physician. This observation held true regardless of job classification.

We asked all our patients if they thought they had returned to work too soon, or if they thought they could have gone back sooner. Many were perplexed by the idea that this could be a matter of opinion, and responded that they went back when the doctor told them, for, "after all, he should know." However, most were induced to express their own opinions and these are

TABLE 10

RETURN TO WORK*

Determined by	P		V.A.		C		Total	
	No.	Av. range	No.	Av. range	No.	Av. range	No.	Av. range
M.D.	22	37.5 (21–70)	12	42.6 (21–63)	3	42.0 (21–56)	37	39.5 (21–70)
Patient								
Felt able	24	16.8 (6–56)	16	26.1 (5–70)	2	20.0 (12–28)	42	20.5 (5–70)
Seasonal lay-off	3	42.0 (28–56)	3	46.7 (28–84)			6	44.3 (28–84)
Vacation	3	61.0 (52–70)	1	84.0 (84)	5	33.2	4	66.8 (52–84)
Total	52	28.8	32	36.2	10		89	30.6

* All ranges and averages are in postoperative days.

TABLE 11
RETURN TO WORK*

Determined by	P			V.A.			C			Total		
	No	Yes	%	No	Yes	%	No	Yes	%	No	Yes	%
M.D.	22	16	73	12	5	42	3	1	33	37	22	59
Patient												
Felt able	24	8	33	16	1	6	2			42	9	21
Seasonal layoff	3	3	100	3	2	67				6	5	83
Vacation	3	3	100	1	1	100				4	4	100
Total	52	30	58	32	9	28	5	1	20	89	40	45

* Patients opinion—could have returned sooner.

tabulated in TABLE 11. The same two groups were employed as in the previous table; that is, patients whose time of return to work was decided by a physician and patients who themselves determined when to return. We also analyzed these data with the patients grouped both according to their job classifications and as self-employed or employees.

Those who thought they could have returned to work sooner than they did fell into all 4 job classifications without any particular correlation. More employees than self-employed persons felt they could have returned sooner, but the self-employed returned far sooner than the employees, as shown in TABLE 9, which may explain this difference. As a group, the private patients felt they could have returned sooner than either of the other two groups and, within the private group, almost three fourths of those whose return was controlled by a physician thought they could have returned sooner. Only 6 of the 89 cases felt they had returned to work too soon. Five of them were V.A. cases who reported for work on an average of 40.6 days postoperatively and were sent by a physician. The other individual said that next time he would take a vacation before returning to work.

We wanted to learn what happens to patients between the time they leave the hospital and the day they return to work. This period is often regarded as one of gradually increasing activity that attains a normal degree at about the time the patient returns to work. We suspected that in most cases this is not true, and that the patient's attainment of normal activity does not correlate closely with his return to work. We found that almost all patients with jobs in the first or second classification were more active at home than at work, in either household duties or hobbies. Moreover, those in our series who were retired tended to resume all their preoperative activities earlier than those who had jobs returned to their work.

Data pertaining to this period do not lend themselves well to quantitative tabulations and graphs, for patients often have difficulty recalling the precise time they began to fire the furnace, cut the grass, buy groceries, and do the many other things involved in daily living. However, we were able to obtain some interesting information. The patients invariably remained ambulatory when they arrived at home, some taking an occasional nap. They climbed stairs as desired, and usually they were walking about outdoors and driving their cars in less than 7 days. Almost all patients with small children lifted them within 1 week of their return home; these children ranged in weight from 15 to 50 lb. Those of our patients who had coal-burning furnaces usually shoveled the coal themselves, sometimes beginning on the day they returned from the hospital. Many patients who underwent surgery during the winter months shoveled snow in less than 2 weeks after the operation. It appears that patients are quite apt to perform their usual domestic activities at an early date.

Patients were quick to resume their hobbies. A 36-year-old patient who returned to a job in the second classification on his fourteenth postoperative day began lifting 180 lbs. over his head on the eighth postoperative day because his hobby was weight lifting. Another, who was 55, returned to his job in the first classification on his forty-second postoperative day, but had built a boat during his convalescence. One patient went swimming every day beginning on the twenty-ninth day after surgery, but did not return to his job in the fourth classification for another 3½ weeks. Others took trips, worked in basement shops, or did gardening during their convalescence. In fact, one patient used his convalescence to go deer hunting during the second postoperative week. Carrying the deer did not seem to overstrain his herniorrhaphy. The many examples show that with rare exceptions patients resumed their avocations long before their vocations, with little concern for which might prove the more strenuous.

Patients who did limit their activities did not do so because of pain or swelling, for these were infrequent developments, nor did they do so because of weakness, for it appeared that the weakness occurred secondarily to the inactivity. They did so because of fear, a fear that the wound would disrupt. Some had fear as a consequence of ignorance of the operation and its implications, others acquired their fear from friends, neighbors, fellow patients, and physicians.

Our study was not directed primarily at the incidence of recurrence, but there were three recurrences in our series. We wish merely to point out that the recurrences were in the group kept from resuming work by a physician. One of these patients, upon his release from the hospital on the seventh day, was immediately put in bed by his wife for another week. After this week of bed rest he was permitted very limited activity at home, not even being allowed to dry the dishes. Three weeks later he returned to a job in the fourth classification. Neither of the other two patients with recurrence indulged in any unusually vigorous activity during their convalescence.

Consequently, we must conclude that convalescence does not usually extend to the time when a patient returns to work. If the physiological convalescent period ends, by definition, when a patient is able to carry on his normal activities without difficulty or damage, then in our experience with this series, convalescence usually is terminated inadvertently by the patient some time before he actually returns to work. The day of return to work is determined by psychological, sociologic, medicolegal, and economic factors, rather than by physiological considerations.

The emphasis on time intervals and activity restrictions in the management of wound healing frequently appears to us to be misdirected. A patient is regularly subjected to strains more likely to cause recurrences in the normal processes of coughing, sneezing, and straining at stool. It is our opinion that normal activities to which the patient is accustomed are an aid, not a deterrent, to good wound healing. The long delays in returning patients to normal activity assume great economic significance to the individual and to the nation.

Of greater significance, it seems to us, is the fact that the medical profession has not developed the necessary information to determine many of the factors related to this problem. Our small series, although carefully studied, and others like it, represent only a beginning. An extensive study begun on patients entering the hospital for operation and continued with careful follow-up could yield much valuable information. We still have much to learn if we are to assume responsibility for the posthospitalization management of operative cases.

RETURN TO WORK AFTER SURGERY: AN INDUSTRIAL STUDY

By Allan J. Fleming
E. I. du Pont de Nemours & Company, Wilmington, Del.

The many advances made in recent years in the preparation of patients for surgery, in anesthesia, blood replacement, control of electrolytes, and in surgical technique, including the control of infection and postoperative care, have shortened hospital stay considerably, despite the complexity of many of today's surgical procedures. Surgical treatment is now available for many conditions, involving particularly the heart and lungs, that seriously reduced the life expectancy of those affected a generation or two ago. New approaches may further modify surgical care by shortening wound healing and convalescence. It was not many years ago that John H. Powers[1] demonstrated the benefit of early postoperative activity in shortening convalescence after surgery. More recently, Ian G. McDonald[2] has advocated exposure-suction treatment for surgical wounds, particularly in radical surgery, to promote more rapid healing of the wound. As a result of such studies, hospital stay is being shortened. During the period from 1945 to 1950, average hospital stays for general surgical operations were shortened by about five days.

The subject of return to work after surgery is of more than passing interest to industry today, for many industries have employee benefit plans that may involve full or partial payment of wages as well as insurance benefits during an employee's absence from work due to illness. In my own company, benefits begin for salaried employees on the first day of disability and for wage-earning employees on the third day of disability. In addition, all employees have accident and health insurance policies that pay benefits beginning on the eighth day of disability and continuing for a maximum period of thirteen weeks. The cost of these benefits is considerable. It is important, therefore, to keep the period of disability in each case to the lowest possible level consistent with good surgical care and employee safety.

The purpose of this industrial study was to determine whether early ambulation, shortened hospital stay, and shortened convalescence after the more common surgical procedures have reduced the period of disability. Comparative data are scant and current welfare plans probably reduce the incentive to return to work quickly below what it would be if income stopped during absence for illness.

The information in this report was obtained from the accident and health insurance claims for nonoccupational illness during 1956 of a company population of some 90,000 employees. Geographically, most of these employees live in the states east of Chicago and north of the southern border of Tennessee and North Carolina. The data were processed by the Biostatistics Section of our Medical Division under the direction of Sidney Pell.

Information from the insurance claims was transferred to a code sheet containing a list of every item of information relevant to this study. This included the cause of disability classified according to the International Statistical Classification of Diseases, the number of days of disability, age, sex, location, and whether the employee received a wage or a salary. Spaces were provided on the code sheet to enter the information in the form of a punch-card code. The information from the code sheets was then transferred to punch cards by a key-punch operator. The cards were verified for accuracy and then sent to one of the company's electronic computers for processing.

The first step in the processing of the data was the transfer of the information on the cards to tape by means of a card-to-tape converter. Three tapes, known as input tapes, were required for the processing: one tape containing the medical and personal information obtained from the insurance claim, which was transferred from the punch cards; a second, containing the company population and the population of each department and each location broken down by age, sex, and salary or payroll classification, for the computation of illness rates; a third, containing instructions to the machine on how the information on the other two tapes was to be processed.

The computer utilized these three tapes to perform all the necessary computations and to arrange the results in the sequence desired for the report. The data so processed were transferred to output tapes, which were fed into a high-speed printer that prints each sheet of tabulations in from two to six seconds. These statistics have furnished some indication of the degree of association of length of convalescence following surgery to age, sex, occupation, and geographical location.

TABLE 1 shows the mean days of disability for two common operations, appendectomy and herniorrhaphy, on which data have been recorded over a period of about 40 years, largely with reference to male employees. It is interesting that the average number of days lost following appendectomy by male workers between 1915 and 1924 is almost the same as the average number of days lost by our wage-earning group in 1956. Our 1956 experience with days lost following appendectomy and herniorrhaphy compares favorably with the series reported by Powers in 1944 with his emphasis on the abuse of rest as a therapeutic measure following surgery.

As indicated in TABLE 1, other series reported between 1921 and 1946 show

TABLE 1

COMPARISON OF DISABILITY FOR APPENDECTOMY AND HERNIOPLASTY

Mean calendar days absent

References	Period	Worker group	Appendectomy		No. cases	Hernio-plasty	No. cases	Population studied
			Male	Female		Male		
Brundage[3]	1915–24	Mixed	30.8	43.6	184	—	—	1950–3000
Brundage[4]	1921–22	Auto (Flint)	47.0	—	104	55.6	40	21,000
	1921–22	Auto (Pontiac)	35.7	—	78	49.1	36	
Brundage[5]	1924	Industrial	48.8	—	72	53.3	31	114,065
Gafafer[6]	1940–46	Industrial	42.9		2542	55.4	1324	133,000
Powers[1]	1944	Mixed	33.6	(M. & F.)	22	39.2	78	100
	1956 Du P.	Wage roll	30.3	26.2	376	40.1	518	90,000
	Du P.	Salary roll	25.0	29.0		32.0		

TABLE 2
DISABILITY FOLLOWING SURGERY IN DAYS (1956)

	No. cases	Mean	S.D.	C.V.
Appendectomy	376	28.6	12.9	45.1
Hernia of abd. cavity	518	37.6	16.3	43.3
Pilonidal cyst	116	27.2	11.4	41.7
Hemorrhoidectomy	432	25.2	9.9	39.1
Tonsillectomy	269	15.4	6.3	41.1
Anal fissure & fistula	121	26.3	12.6	48.0

far more days of disability following both appendectomy and herniorrhaphy than either the 1944 series reported by Powers or our own 1956 series. If our data are typical for these two operations, it would appear that improved surgical technique, early mobilization, and in-plant medical supervision have resulted in earlier return to work, despite the fact that loss of income is no longer an important incentive to return to work early.

TABLE 2 lists the days of disability following surgery for six common conditions. The cases reported include males and females, as well as salaried and wage-earning employees.

As might be expected, there is a considerable difference in the mean days of disability and the standard deviation of the mean for the operations listed in TABLE 2. However, the numerical similarity of the coefficients of variation suggests that the unmeasurable factors operating to produce variations in the period of disability are not only constant, but also independent of the operation performed. This implies that the period of disability may depend more on the patient than it does on either the surgeon or the type of operation performed. Our data show that the mean period of disability for the operations listed in TABLE 2 is about the same, irrespective of the part of the country in which the surgery is performed.

TABLE 3 shows that males tend to lose less time than females after similar

TABLE 3
MEAN AND STANDARD DEVIATION OF NUMBER OF DAYS OF DISABILITY BY SEX AND PAYROLL CLASS (1956)

		Mean	Standard deviation	No. of cases
Hemorrhoidectomy	Male wage	26.1	9.4	275
	Male salary	22.8	8.9	104
	Female wage	26.1	13.3	40
	Female salary	22.8	11.7	13
Appendectomy	Male wage	30.3	14.4	232
	Male salary	25.0	10.0	87
	Female wage	26.2	8.7	32
	Female salary	29.0	8.0	25
Herniorrhaphy	Male wage	40.1	15.6	351
	Male salary	32.0	16.8	157
	Female wage	42.0	17.0	5
	Female salary	34.4	11.0	5
Displacement of intervertebral disc treated surgically	Male wage	86.7	25.6	67
	Male salary	76.3	34.2	8

operations and that salaried employees lose less time than wage-earning employees. It has been reported[6] that disability following surgery is longer for those more than 50 years old than it is for those less than 50. Our experience at present indicates relatively little association between age and the length of disability in a population between 20 and 65 years of age.

If the trend to shorter hospital stay following surgery is definite, one would expect it to be reflected in earlier return to work, but this does not seem to be the case. Scatter charts show no correlation between the number of days in the hospital and the number of days of disability following appendectomy (FIGURE 1), herniorrhaphy (FIGURE 2), hemorrhoidectomy (FIGURE 3), and intervertebral disc (FIGURE 4).

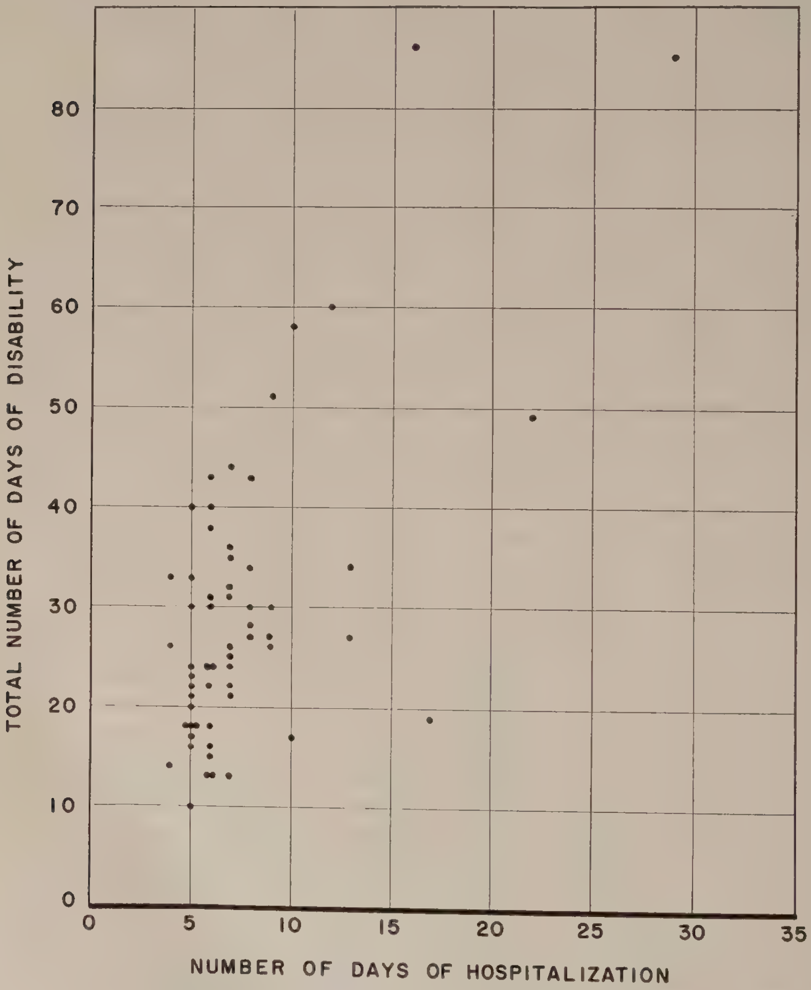

FIGURE 1. Scatter chart showing relation of total number of days of disability to number of days of hospitalization for appendectomy.

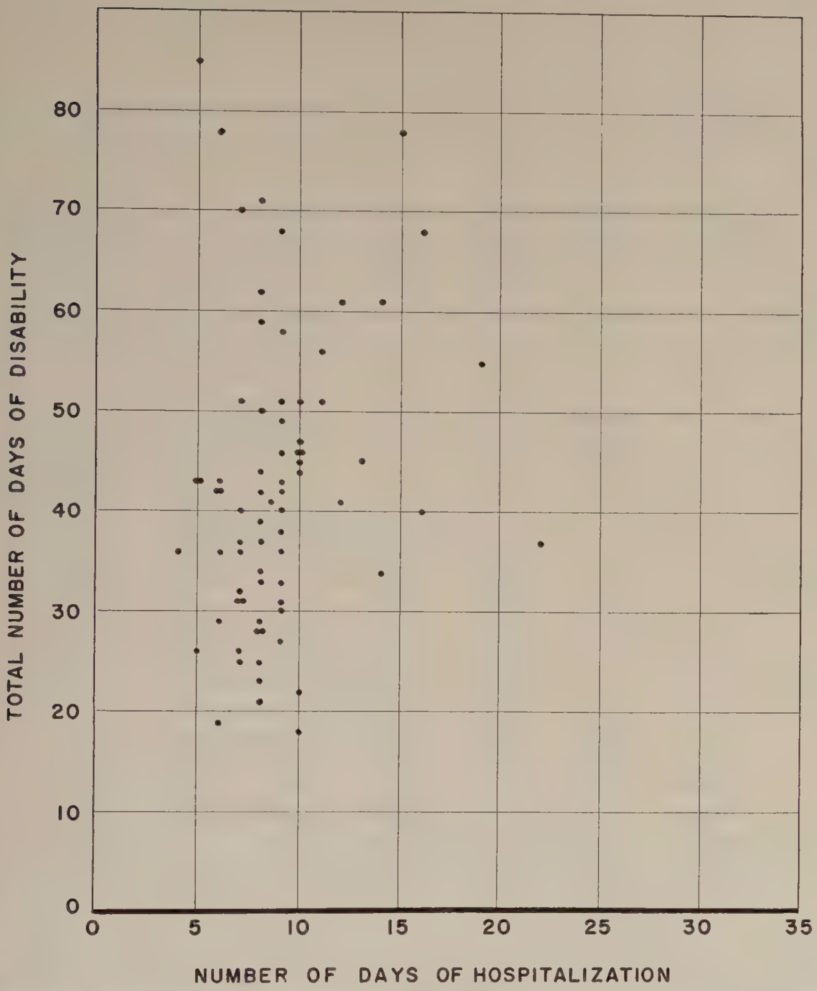

FIGURE 2. Scatter chart showing relation of total number of days of disability to number of days of hospitalization for herniorrhaphy.

Why there should be no correlation is not clear. Perhaps it has become the custom for surgeons to send the patient home from the hospital early, leaving to the general practitioner further postoperative care, as well as the decision as to when the patient may return to work.

The range of days in the hospital and the range of disability for four operations is indicated in TABLE 4.

We feel that our experience with respect to disability following surgery is favorable; at least, we have been told that this is so by accident and health insurance carriers. In part, I think this can be attributed to the close attention and supervision given to disability by our physicians in various plants across the country. One aspect of their work is to know the requirements of

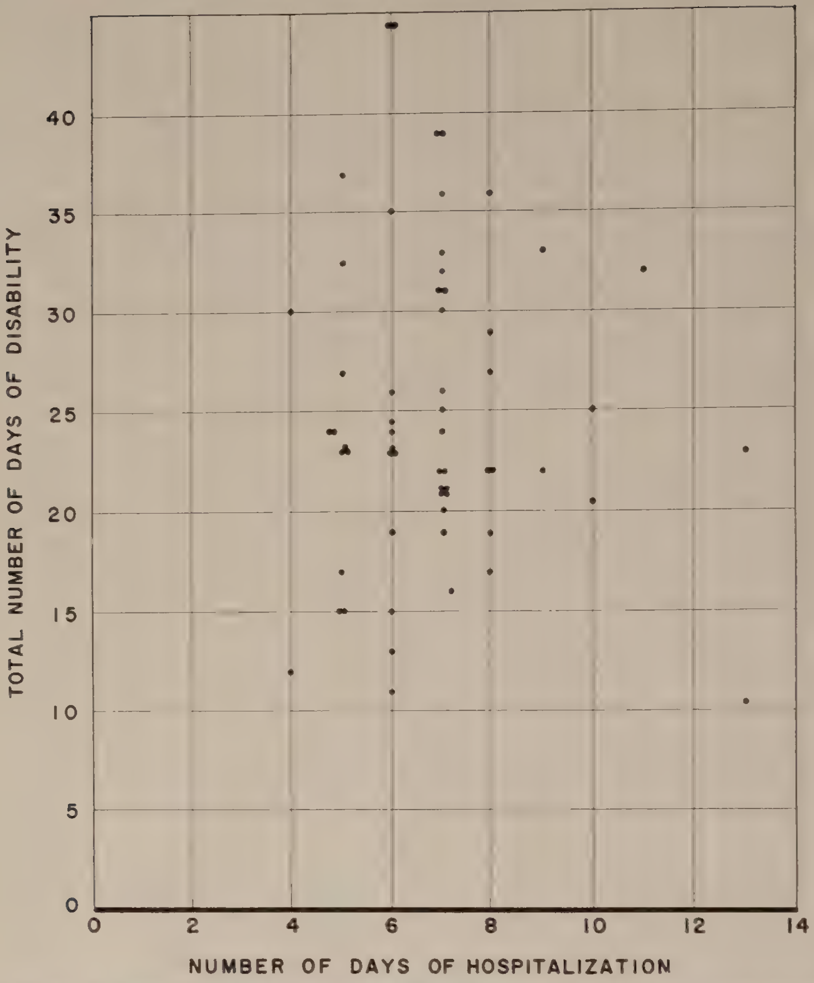

FIGURE 3. Scatter chart showing relation of total number of days of disability to number of days of hospitalization for hemorrhoidectomy.

each job in a plant, and they are in an excellent position to advise whether an employee is fit to return to his job. If the plant physician entertains any doubts, he consults the surgeon further, before deciding.

In conclusion, our findings indicate that the period of convalescence after surgery is influenced by sex and payroll classification, but that it is not influenced by the geographical distribution of employees or by the length of stay in the hospital following surgery.

To assess the influence of the surgeon in the variation of surgical disability, it would be necessary to study an appreciable number of cases treated by the same group of surgeons to determine how disability is influenced by individual surgical practice.

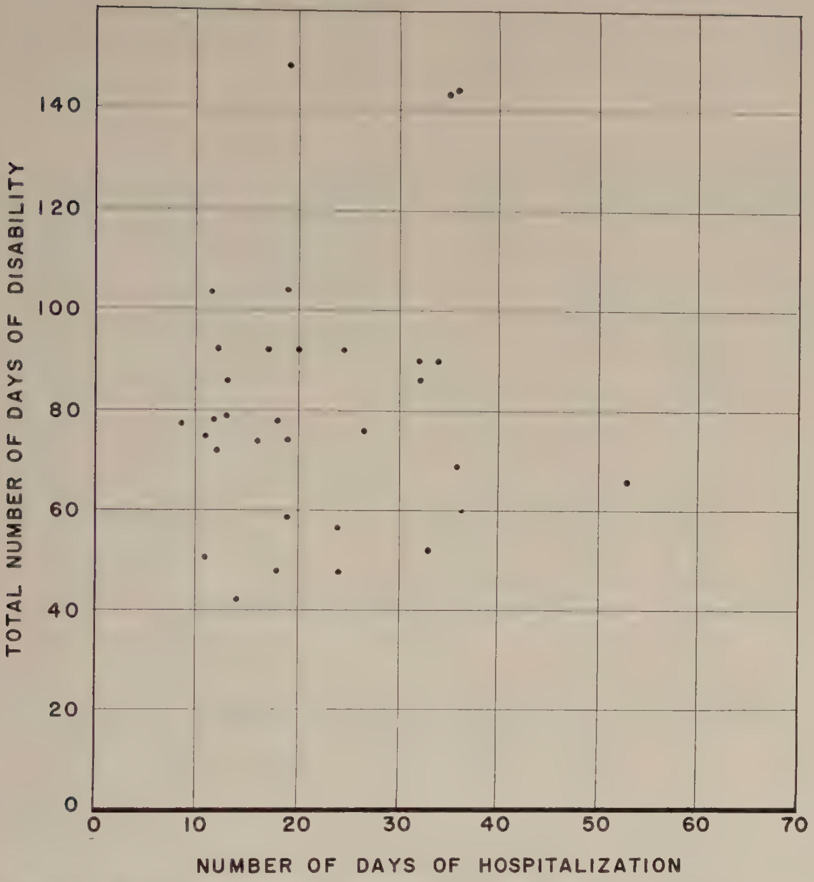

FIGURE 4. Scatter chart showing relation of total number of days of disability to number of days of hospitalization for intervertebral disc.

TABLE 4

	Range of days in hospital	Range of days of disability
Herniorrhaphy	5–10	20–80
Appendectomy	3–7	10–43
Hemorrhoidectomy	4–10	12–38
Surgical disc	10–36	40–150

I make one plea to surgeons. When you are satisfied concerning the surgical recovery of a patient, leave the decision as to return to work to the plant physician, if the patient's company has one. A well-trained and experienced industrial physician knows the nature of the employee's job and is better able to judge whether the employee should go back to full-time, or part-time work, or be assigned temporarily to another job. The addition of another two-week period of convalescence merely for the sake of safety can often be avoided by so doing. Keeping people gainfully employed is our job. An unnecessary extension of convalescence is waste, and today, the price of waste is high.

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EARLY AMBULATION AND RETURN TO FULL DUTY IN THE UNITED STATES AIR FORCE

By David Gold

Office of the Surgeon General, United States Air Force, Washington, D. C.

Early ambulation has been practiced in the United States Air Force for the past several years. This practice was not established by decree. The major portion of our surgery is performed by fairly young individuals who were introduced to this principle during their residency training.

Our concern for maintaining the lowest possible noneffective rate in our military personnel commensurate with good medical practices stems from several basic considerations. The end product of our activities is to maintain a state of battle readiness in selected organizations. This can be vitiated by the protracted absence of even a few individuals who may occupy special positions. Since constant manpower turnover of greater or lesser degree has been part and parcel of the military forces, the state of health of our personnel in various stages of training is actually the key to our state of readiness and occupies the major portion of our daily efforts. We have promulgated such practices within the limitations of our facilities and personnel as will return the military patient to his duty station at the earliest practical date, sufficiently recovered from his illness to allow performance of constructive duties within the assigned mission of his organization.

The definition of "full duty" under these circumstances requires some clarification. The medical officer in charge of the patient being released to duty must take cognizance of the variable factors related to the patient's normal duties. No one, for example, would recommend to a patient that he immediately engage in vigorous physical activities ten days after an inguinal herniorrhaphy. Yet, a large number of patients are returned to duty at this time. Again, our approach to this problem is purely empirical, since there is as yet no unit of measure by which to identify the exact end point of convalescence, that is, the resumption of full capability of resisting all stresses previously acceptable to the patient. To date, experience alone has been our guide to the adequacy and effectiveness of this approach.

At the earliest date when the patient's wound appears to be healing well, his muscle tone seems satisfactory, his vasomotor system appears stable, he has been ambulating from the first or second postoperative day, and his appetite is good, we would normally consider this man ready for return to his duty station. A highly desirable addition to our efforts in rehabilitation during the convalescent period would be a strict program of graduated physical exercises to return the patient to maximal physical effort in a minimal time. This can be practiced in only limited situations.

The principle of retraining or cross-training is essential for the realization of maximal utilization of available manpower. This aspect of effectiveness may be considered by the medical officer at the time of a patient's release from the hospital, and such recommendations will be made to the man's organization commander where indicated.

The statistical studies I wish to present are frequency curves of 10 per cent samplings representing approximately 10,000 operative procedures. Frequency curves covering our 1956 data on appendectomy, inguinal herniorrhaphy, tonsillectomy, and hemorrhoidectomy show a range of reliability of plus or minus 2 of the mean days lost. These frequency curves identify the percentage of cases remaining in the hospital on any specific day after operation. Three points on each frequency curve have been selected as convenient values for purposes of comparison. They are the postoperative day on which 50 per cent, 75 per cent, and 90 per cent of the patients have been returned to duty.

The inordinate delay in return to duty of some of the patients in this last group is not detailed, since it is not germane to our thesis. Suffice it to say that complicating factors, both medical and administrative, were present.

The frequency curve for appendectomy (FIGURE 1) is represented on this first slide. The patients are all male military personnel. No distinction as to rank or age has been made, since previous studies and a quick survey of the present available material indicated no statistically valuable variations of this curve. This sampling represents approximately 2800 cases admitted to the hospital with this single diagnosis. The mean or average days lost from the day of operation to return to duty is shown here as 12.3 days. It is more significant to examine the curve and see at what point various percentiles of these cases returned to duty. Actually, a number of patients were back at their jobs in 3 to 5 days. Fifty per cent of them were returned to duty in 9 days. To carry this further, 75 per cent were discharged in 14 days, which is within 2 days of the mean duration. Finally, 90 per cent were discharged by the twenty-first day. The remaining 10 per cent had complications secondary to their surgery, were given convalescent or other administrative leave, or were exceptions in other ways.

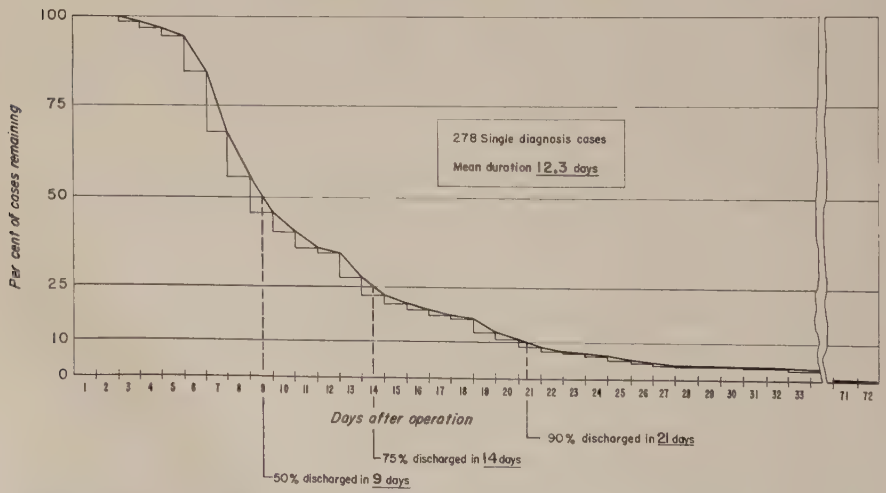

FIGURE 1. Frequency curve of a 10 per cent sampling of 1956 appendectomy patients showing duration of hospitalization after surgery.

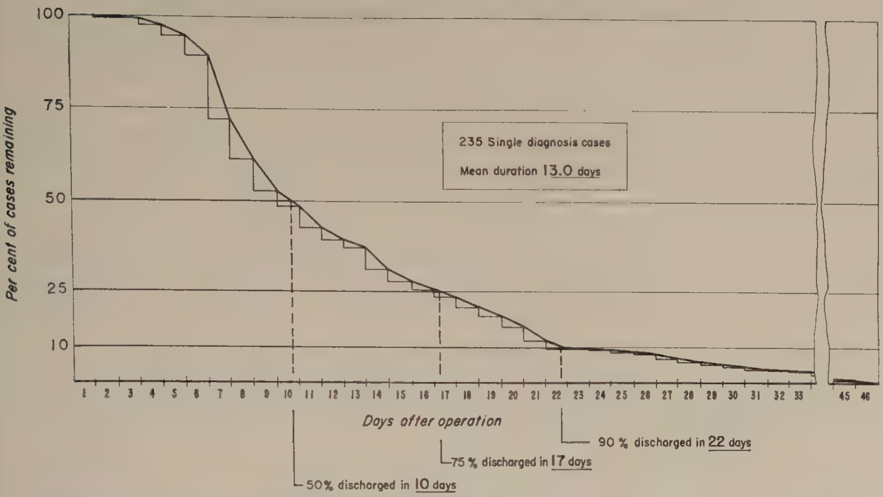

FIGURE 2. Frequency curve of a 10 per cent sampling of 1956 inguinal herniorrhaphy patients showing duration of hospitalization after surgery.

In the light of biostatistics, another significant figure derived from the frequency curve is the modal duration, that is, the duration most frequently reported, which is shown by the point where the drop in the curve is the steepest. As can be seen in FIGURE 1, the drop is most precipitous at about the seventh postoperative day; it represents about 30 per cent of the patients, all of whom left the hospital during an approximate 48-hour period. On the basis of this figure we could say ideally that, if our relatively uncomplicated surgery for the single problem found on admission were followed by an uncomplicated convalescent period incorporating early ambulation, we could expect the greater portion of our appendectomy cases to be returned to duty by the seventh postoperative day. It is hoped that, at some future date when all our records are transcribed on IBM punch cards, we can assemble a more accurate picture of the modal duration.

The frequency curve in FIGURE 2 represents approximately 2400 cases of inguinal herniorrhaphy. Again, the mean or average duration of days lost from surgery until return to duty was 13.0. Nevertheless, 50 per cent were discharged from the hospital by the tenth postoperative day, 75 per cent by the seventeenth day, and 90 per cent by the twenty-second day. The steepest point in the curve, that is, the modal duration, is in the area of the sixth to ninth days, which represents a good 35 per cent of the cases. The 10 per cent at the lower end of the curve represents exceptions similar to those previously mentioned. It would be interesting at some future date to set up frequency curves for different installations. We could then compare with more consistency some of the variables of postoperative management. Such a comparison would identify the most acceptable durations that one could determine by such an empirical approach.

FIGURE 3 is a sampling of 2200 cases of tonsillectomy. The mean duration is 5.2 days. This curve has almost a uniformity in steepness for approximately

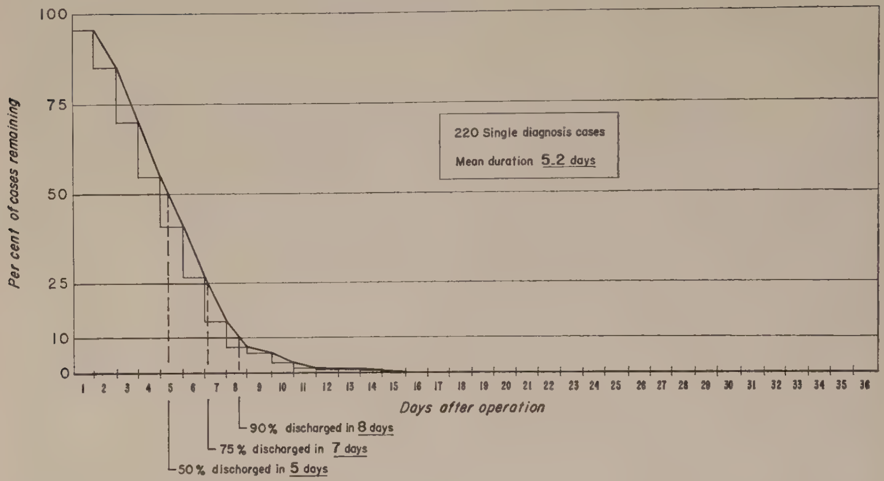

FIGURE 3. Frequency curve of a 10 per cent sampling of 1956 tonsillectomy patients showing duration of hospitalization after surgery.

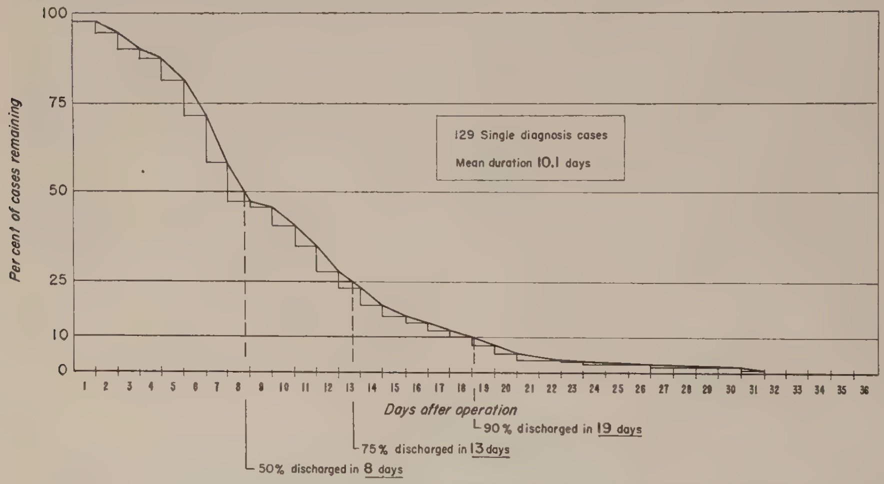

FIGURE 4. Frequency curve of a 10 per cent sampling of 1956 hemorrhoidectomy patients showing duration of hospitalization after surgery.

80 per cent of the cases within a 4-day period. It probably represents the most ideal graphic situation one could hope to have.

The frequency curve for hemorrhoidectomy (FIGURE 4) represents a total of approximately 1300 cases. The mean duration is 10.1 days. The highest number of discharges occurred between the fifth and eighth days and amounts to about 30 per cent of the cases. In 8 days 50 per cent of the cases had been discharged, in 13 days 75 per cent, and in 19 days 90 per cent. This frequency curve appears fairly consistent with those for appendectomy and herniorrhaphy.

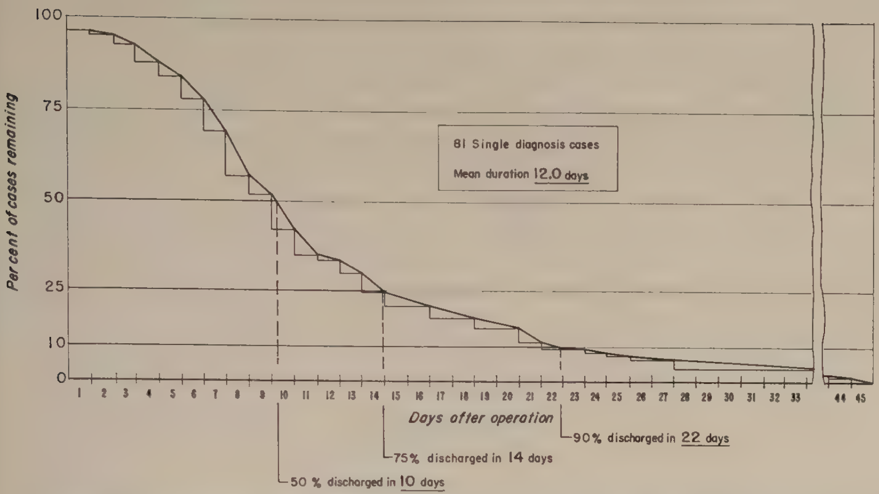

FIGURE 5. Frequency curve of a 10 per cent sampling of 1955–1956 saphenous ligation (and/or phlebectomy) patients showing duration of hospitalization after surgery.

The sampling for the frequency curve (FIGURE 5) on saphenous ligation and stripping represents procedures performed during 1955 and 1956. Again, these are single-diagnosis cases, and the 10 per cent sampling represents approximately 810 cases. This curve has a more gradual slope with no significant modal duration, except perhaps that of the eighth day, which indicates a 10 per cent discharge rate. However, 50 per cent of the cases were discharged in 10 days and 75 per cent in 14 days, which is only 2 days more than the average duration of 12 days. Ninety per cent were returned to duty in 22 days. Since this sample is numerically far smaller than those for the previous curves shown, the range of reliability for the mean days lost has a somewhat greater spread than that of the previous curves.

In order to provide a sample for thyroidectomies performed on nontoxic nodular goiter as the single diagnosis for admission, it was necessary to search the records for the years 1954 through 1956. This is not an adequate or reliable survey, since only 16 cases are included in the sample, representing a total of approximately 160 operations (FIGURE 6). However, it does indicate a trend, which is perhaps significant in that 75 per cent of these cases were discharged to duty in 16 days. Let me point out again that these are male military personnel only.

We have a similar problem in evaluating this last curve for cholecystectomy (FIGURE 7). The size of the sample is numerically so small that the range of reliability of the mean duration could be plus or minus 5 days of the average shown. It is projected here only to indicate a general trend.

Professional differences of opinion primarily account for the spread in the duration of the convalescent period for at least 90 per cent of the cases represented in the curves of the figures presented above. Such factors as motivation, compensation, and personal gain are not treated as significant in the

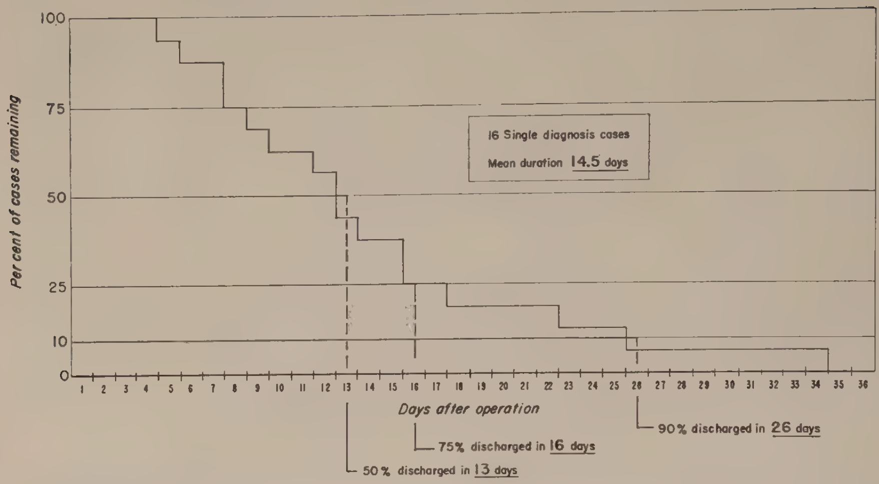

FIGURE 6. Frequency curve of a 10 per cent sampling of 1954–1956 thyroidectomy (nontoxic nodular goiter) patients showing duration of hospitalization after surgery.

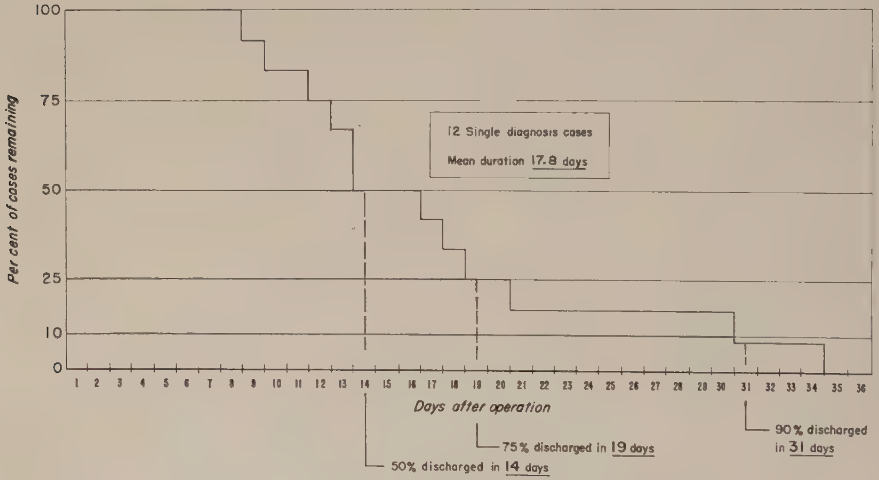

FIGURE 7. Frequency curve of a 10 per cent sampling of 1954–1956 cholecystectomy patients showing duration of hospitalization after surgery.

military. Technically the patient has duty status during his hospitalization and is under complete control of the military surgeon.

This survey consists of material initially uncomplicated in nature, except for the specific disorders indicated. The required surgical procedures did not necessitate any unusual surgical manipulation to correct the disorders. We feel that the practice of early ambulation, which has been in vogue for several years, undoubtedly accounted for an over-all reduction of the convalescent period. No effort was made to dictate an acceptable range for the period of convalescence. This study is purely empirical and represents the experience of approximately one hundred surgeons whose formal postgraduate training ranges from a minimum of one year to a maximum of six years. We urge that the frequency curve be utilized in future presentations of similar statistical material.

EARLY AMBULATION: ITS INFLUENCE ON POSTOPERATIVE COMPLICATIONS AND RETURN TO WORK FOLLOWING HERNIOPLASTY IN A RURAL POPULATION

By John H. Powers

The Mary Imogene Bassett Hospital, Cooperstown, N. Y., and the Department of Surgery, College of Physicians and Surgeons, Columbia University, New York, N. Y.

Introduction

During the early years of modern surgery, prolonged periods of rest in bed were considered essential for the proper healing of abdominal incisions. The attitude of distinguished surgeons and teachers of surgery, both here and abroad, was one of conservatism based in no small measure on the teachings of Bilroth who believed that rest and protection were essential for proper repair of coapted tissues.

Writing on the radical cure of inguinal hernia in 1892, Halsted stated: "Our patients are kept upon their backs for twenty-one days. Wounds healed thoroughly throughout *per primam* are not strong in eight days . . . are certainly stronger on the fourteenth day than on the seventh, and stronger on the twenty-first day than on the fourteenth. Just how long wounds of skin and muscle which have healed by first intention continue in strength we do not know. . . . I sometimes question the propriety of allowing, as I do, my patients to walk about on the twenty-first day."[1]

Nevertheless, the following year, Emil Ries, who may properly be called the father of early postoperative ambulation, instituted successfully an abrupt and radical departure from this traditional method of postoperative management.[2] Ries was professor of gynecology at the Post-Graduate Medical School, Chicago, Ill. While visiting Morisani's Clinic in Naples, Italy, in 1893, he was shown a patient who had risen from bed and walked across the ward during the evening of the day of symphysiotomy without detriment to herself or the wound. Prompted by his recollection of this Italian patient, Ries, after his return to Chicago, allowed his own patients far greater freedom. Those who underwent intra-abdominal work done by the vaginal route were permitted to be up and walking about within hours of recovery from anesthesia. The success of this program was so gratifying that the method was soon utilized also in the postoperative management of patients following laparotomy. Not only were these patients ambulated promptly but Ries discovered that those "who got up early and whose bowels acted regularly and easily presented another symptom which necessitated a further change in customary after-treatment. These patients were hungry—they were not satisfied with milk and soup and other liquids." Accordingly, meat, bread, vegetables, and solid food were allowed "as soon as peritonitis was proven to be absent, often as early as twenty-four hours."

His paper concludes with the following paragraph: "The changes which I have reported here have not to my knowledge been carried out anywhere else to this extent. I can assure you that with the proper asepsis and with the proper method of suture they can be introduced anywhere, not only without detriment to our patients, but to their positive gain and advantage. It means a great deal for a business man or a laborer, or their wives, to be put on their own feet in a short time and to be able to return to their work two or three weeks after an abdominal operation."

Early postoperative walking was also adopted by H. J. Boldt[3] of New York, N. Y., another gynecologist and a friend of Ries, who wrote: "Occasionally I have done abdominal hysterectomies for fibroids, panhysterectomies for purulent inflammatory conditions, ovarian tumor operations, etc., in the morning and have had my patients out of bed in a rocking chair late in the afternoon of the same day." In 1907 these two gynecologists had a combined series of nearly 900 patients who had been allowed up on the first and second days after laparotomy with "not a single instance of untoward result which could in any way be attributed to the early rising from bed."

Boldt's paper concludes: "I have gained the impression that the mortality rate is lower" (among the patients treated by early postoperative ambulation); "next, there is less nausea and vomiting, also less abdominal distention, because flatus is passed more readily when patients are sitting up. Spontaneous action of the bowels occurs earlier. There is less liability to bronchial and pulmonary complications. There is less liability to circulatory disturbances. There is better assimilation of food. There is less weakening of the general physical condition of the patient. In short, there is more rapid recovery to working ability."

These observations and impressions of a few surgeons one half a century ago, are evaluated in this monograph in the light of modern science. Other contributors discuss the endocrinological, metabolic, and biochemical aspects of surgical trauma, and the physiological and psychological effects of inactivity on the human organism. I propose to present some practical observations on the influence of early ambulation on the incidence of postoperative complications, the rate of recurrence, and the resumption of normal activity after hernioplasty in a rural population.

Clinical Data

Hernioplasties have been selected for study because of the fairly standardized nature of each type of hernial repair, because of the usual absence of infection as a postoperative complication, because of the ready availability of statistics relative to return to work, and because I had previously reviewed all the hernioplasties performed at the Bassett Hospital from 1933 through 1948 in an earlier study of prompt postoperative activity.[4] Among these were inguinal, femoral, epigastric, umbilical, and ventral hernias, various combinations of each with inguinal ruptures, diaphragmatic and internal hernias, and 2 cases of abscesses in inguinal sacs: a total of 467 operations (TABLE 1). These patients were grouped according to the rapidity of postoperative mobilization. "Late" applies to ambulation that was not undertaken until the tenth or twelfth postoperative day, in other words, to the traditional postoperative program that was followed at the hospital until 1940. "Delayed" refers to ambulation com-

TABLE 1
SURGICAL CONVALESCENCE
Clinical study following hernioplasty*

Tabulation of cases	Number of operations							
	1933–1948					1949–1953		
	Adults					Adults		
	Ambulation					Amb.		
	Late	Delayed	Early	Children	Total	Prompt	Children	Total
Unilateral inguinal	103	12	161	52	328	240	43	283
Bilateral inguinal	6	0	27	5	38	39	5	44
Unilateral femoral	18	5	12	1	36	24	0	24
Umbilical	6	1	5	13	25	15	2	17
Epigastric	6	0	1	0	7	6	1	7
Postoperative ventral	10	2	7	0	19	19	0	19
Post-traumatic ventral	1	0	0	0	1	0	0	0
Inguinal and umbilical	0	0	1	0	1	0	0	0
Inguinal and ventral	1	0	1	0	2	1	0	1
Inguinal and femoral	2	2	1	0	5	2	0	2
Inguinal and epigastric	0	0	0	0	0	0	1	1
Diaphragmatic	1	0	1	0	2	7	0	7
Internal	1	0	0	0	1	0	0	0
Abscess in inguinal sac	2	0	0	0	2	1	0	1
Total	157	22	217	71	467	354	52	406

* Tabulation of varieties of hernias in relation to rapidity of postoperative ambulation, 1933 to 1953, inclusive.

mencing on the second, third, or fourth day. "Early" activity connotes rising from bed and walking on the first day after operation.

For comparison with my previous studies, I have now reviewed an additional 406 hernioplasties—also of various types and in about the same proportion as the earlier series shown in TABLE 1—which were performed during the years 1949 through 1953. During this interval all patients were out of bed on the afternoon or evening of the day of operation. "Prompt" is used to describe this most recent type of postoperative ambulation.

No attempt has been made to grade the activity of "children"; this category includes all those from birth through 12 years of age.

Numerous preoperative conditions not infrequently associated with or complicating the hernias in each group of patients are tabulated in TABLE 2. Varying degrees of incarceration and strangulation of the omentum, intestine, and colon, with and without intestinal obstruction, occurred with about the same comparative frequency among the patients who were ambulated late, early, and promptly. The existence of these complications prior to repair of the hernia neither delays nor influences adversely the acceleration of postoperative activity.

TABLE 2
SURGICAL CONVALESCENCE
Clinical study following hernioplasty*

Associated preoperative complications	Hernioplasties performed							
	1933–1948					1949–1953		
	Adults					Adults		
	Ambulation					Amb.		
	Late	Delayed	Early	Children	Total	Prompt	Children	Total
None	100	13	175	58	346	292	46	338
Incarceration of omentum	12	0	7	1	20	17	0	17
Incarceration of intestine or colon	5	0	6	4	15	12	5	17
Incarceration of omentum and intestine or colon	2	0	3	0	5	2	0	2
Incarceration of intestine with obstruction	10	0	8	1	19	9	0	9
Incarceration of acutely inflamed appendix	0	2	1	0	3	1	0	1
Incarceration of tube and ovary	0	0	0	1	1	0	0	0
Incarceration, organ not stated	0	0	0	2	2	0	0	0
Strangulation of omentum	4	1	3	0	8	0	1	1
Strangulation of intestine with obstruction	19	5	12	4	40	17	0	17
Strangulation of omentum and intestine with obstruction	3	1	1	0	5	3	0	3
Strangulation of appendix epiploica	0	0	1	0	1	0	0	0
Abscess due to *E. coli* in hernial sac	2	0	0	0	2	1	0	1
Total	157	22	217	71	467	354	52	406

* Tabulation of associated preoperative complications.

Previously, early ambulation after surgical operations had been found to have no unfavorable effect on the temperature, pulse rate, respiratory rate, blood pressure, or vital capacity.[5, 6]

The original observations of Ries and Boldt concerning the promptly ambulated patient's desire for food, early return of normal intestinal function, and freedom from pain have all been confirmed by my own observations and by those of all other surgeons who have had experience with this modern type of postoperative management.

The remainder of this presentation, therefore, is confined to the effect of early ambulation on the type and frequency of postoperative complications, the incidence of recurrence, and the total convalescent period following hernioplasty.

Postoperative Complications

All the patients were frequently observed, interrogated, and examined for complications during the convalescent period in the hospital. Subsequently, the charts have been carefully reviewed with special attention to symptoms and signs that suggested complications, even though their actual existence may have been only suspected. In the late group there were 15 deaths, usually of elderly patients with strangulation and obstruction for several days before admission to the hospital; the mortality in this group was 10 per cent. One fatality in the prompt group was due to perforation and general peritonitis secondary to strangulation and gangrene; the mortality in this group was 0.3 per cent. There were no deaths in the other 2 groups of adults, or among the children (TABLE 3).

The incidence of total complications among the patients who remained in bed for an average of 11 days after operation was 98 per cent, 1 complication for every operative procedure. The incidence of such complications among those individuals who were ambulated on the second, third, and fourth days, on the first postoperative day, and on the afternoon or evening of the day of operation was, respectively, 86, 53, and 54 per cent (TABLE 3). The favorable influence of early ambulation on the incidence of total postoperative complications is obvious.

All complications have been classified according to the system involved and are recorded in TABLE 4. The incidence of many is not affected by the rapidity of mobilization of the patient after operation. Others are very definitely influenced by prompt ambulation.

The complications of significance, designated by daggers in TABLE 4, are listed separately in TABLE 5 and discussed in some detail below.

Local complications. Hematoma in the wound, cord, testis, or scrotum was twice as common among the patients who were out of bed and walking either

TABLE 3
SURGICAL CONVALESCENCE
Study of postoperative complications following hernioplasty*

Summary Mary Imogene Bassett Hospital 1933–1953, inclusive	Number					
	Adults				Children	Total
	Postoperative activity					
	Late	Delayed	Early	Prompt		
Number of patients operated on	153	22	210	341	121	847
Number of hernioplasties performed	157	22	217	354	123	873
Deaths in hospital	15	0	0	1	0	16
Operative mortality (percentage)	10	0	0	0.3	0	18
Postoperative complications (number)	153	19	115	194	26	507
Incidence of complications per 100 operations	98	86	53	54	21	58

* Summary of data on postoperative complications following hernioplasty.

TABLE 4

SURGICAL CONVALESCENCE

The effect of early postoperative activity on the incidence of complications following hernioplasty*

Complications	Number of complications					
	Postoperative activity				Children	Total
	Late	Delayed	Early	Prompt		
Local						
Hematoma in wound, cord, testis, or scrotum†	6	1	21	22	5	55
Seroma in wound	1	0	2	2	0	5
Infection of wound	5	0	3	3	3	14
Cellulitis of abdominal wall	1	0	0	2	0	3
Stitch abscess	3	1	2	4	2	12
Discharge of nonabsorbable sutures	1	0	1	2	1	5
Acute epididymitis	0	0	0	2	0	2
Disruption of wound (laparotomy)	1	0	0	0	0	1
Total	18	2	29	37	11	97
Cerebral						
Cerebral thrombosis with hemiplegia	1	0	0	1	0	2
Cerebral hemorrhage, suspected	1	0	0	0	0	1
Mental confusion	0	0	0	6	0	6
Post spinal headache†	0	0	0	3	0	3
Total	2	0	0	10	0	12
Cardiac						
Anginal attacks	1	0	0	0	0	1
Coronary thrombosis with infarction of myocardium	2	0	0	0	0	2
Decompensation with pulmonary edema and congestion	2	0	0	1	0	3
"Active isolated" myocarditis	0	0	0	1	0	1
Significant irregularities of cardiac rhythm	0	0	0	3	0	3
Total	5	0	0	5	0	10
Pulmonary						
Nasopharyngitis	0	0	0	4	3	7
Tracheitis	0	0	0	1	0	1
Bronchitis	9	0	8	3	1	21
Bronchopneumonia†	12	2	4	5	3	26
Partial atelectasis†	5	0	8	37	1	51
Massive atelectasis†	2	0	0	0	0	2
Infarct of lung, demonstrable or suspected†	7	1	8	2	0	18
Pulmonary embolism, actual or suspected†	5	0	0	0	0	5
Pleurisy†	4	0	1	0	0	5
Cough, unexplained	4	1	4	1	0	10
Total	48	4	33	53	8	146

Table 4—*continued*

Complications	Number of complications					
	Postoperative activity				Children	Total
	Late	Delayed	Early	Prompt		
Vascular						
Thromphlebitis, superficial or deep†	2	0	1	3	0	6
Thrombosis of deep veins of legs, actual or suspected†	9	1	15	14	0	39
Thrombosis of intrinsic vessels of male genitalia	1	0	0	0	0	1
Embolism of femoral artery	0	0	1	0	0	1
Total	12	1	17	17	0	47
Gastrointestinal						
Persistent hiccoughs	3	0	2	1	0	6
Dilatation of stomach†	6	0	1	0	0	7
Persistent abdominal distention†	16	0	5	3	1	25
Intestinal obstruction	0	0	0	1	0	1
Fecal impaction	0	0	0	1	0	1
Total	25	0	8	6	1	40
Genitourinary						
Postoperative inhibition of bladder†						
Necessitating 1 catheterization only†	4	3	15	32	0	54
Necessitating 2 or more catheterizations†	27	5	9	18	0	59
Cystitis	5	4	2	8	0	19
Acute pyelonephritis	0	0	0	1	0	1
Total	36	12	26	59	0	133
General						
Fever of unknown origin	7	0	2	4	4	17
Dermatitis medicamentosa	0	0	0	3	2	5
Total	7	0	2	7	6	22
Total complications	153	19	115	194	26	507
Total operations	157	22	217	354	123	873
Incidence of complications (percentage)	98	86	53	54	21	58

* Tabulation of all postoperative complications studied in relation to rapidity of postoperative activity.

† Complications of some significance, discussed in the text.

on the day of operation or the following day as it was among those who remained in bed for 10 to 12 days. Since all wounds were dry when closed, it seems probable that early ambulation is conducive to postoperative oozing from tiny vessels that were not bleeding during the operation. Unusually careful hemostasis is imperative when such activity is permitted.

Cerebral complications. Persistent headache was present in 3 patients who were ambulatory within a few hours after hernioplasty under spinal anesthesia.

TABLE 5

SURGICAL CONVALESCENCE

The effect of early postoperative activity on the incidence of significant complications following hernioplasty*

Complications	Number of complications			
	Postoperative activity			
	Late	Delayed	Early	Prompt
Hematoma in wound, cord, testis, or scrotum	6	1	21	22
Post spinal headache	0	0	0	3
Bronchopneumonia	12	2	4	5
Partial atelectasis	5	0	8	37
Massive atelectasis	2	0	0	0
Infarct of lung, demonstrable or suspected	7	1	8	2
Pulmonary embolism, actual or suspected	5	0	0	0
Pleurisy	4	0	1	0
Thromphlebitis, superficial or deep	2	0	1	3
Thrombosis of deep veins of legs, actual or suspected	9	1	15	14
Dilatation of stomach	6	0	1	0
Persistent abdominal distention	16	0	5	3
Postoperative inhibition of bladder				
Necessitating 1 catheterization only	4	3	15	32
Necessitating 2 or more catheterizations	27	5	9	18
Total complications of significance	105	13	98	139
Total operations	157	22	217	354
Incidence of complications (percentage)	67	59	45	39

* The effect of early ambulation on significant complications.

Such headache did not occur among the patients in other categories, regardless of the type of anesthesia.

Pulmonary complications. Bronchopneumonia occurred less than one fourth as often among the patients who were ambulatory within 24 hours. It is unlikely that this lowered incidence of pulmonary infection was due to modern chemotherapeutic agents and antibiotics, for these drugs were not used prophylactically. Massive atelectasis was not observed among the early or the promptly ambulated patients. Partial atelectasis was apparently more common among the patients who were out of bed on the day of operation, possibly because, from 1949 through 1953, the members of the resident and attending staffs were more aware of the frequency of this complication and therefore more meticulous in their early examinations of the chest, more prompt in requesting roentgenograms, and more astute in the diagnosis of this transient postoperative pulmonary complication. The incidence of pulmonary infarction due to small emboli, whether proved roentgenographically or suspected clinically, seems to have been significantly reduced by prompt ambulation. Massive pulmonary embolism, with an incidence of 3 per cent subsequent to the 157 operations in the late group, did not occur among those patients who were allowed to get up and walk within 24 hours and to increase their activity rapidly thereafter. Postoperative pleurisy, possibly an indication of smaller emboli not otherwise recognized, was likewise far more common among the patients whose activity was long delayed.

Vascular complications. Thrombosis in the deep veins of the legs was not prevented, nor was the incidence of this complication lowered, by early and prompt postoperative ambulation. After studying the incidence of thromboembolism among 1519 major surgical patients operated on at the Bassett Hospital and reported in 1947,[7] I concluded: "Exercises in bed, ambulation within the first 24 hours . . . and a generally accelerated convalescence permit early return to customary activity. Unfortunately such a program does not favorably influence the incidence of postoperative thrombosis." In the present study the frequency of this complication after hernioplasty offers additional support for these conclusions. It may be, however, that early postoperative activity prevents the formation of a thrombus of sufficient size to precipitate a fatal postoperative catastrophe by massive embolism.

Gastrointestinal complications. Postoperative dilatation of the stomach and persistent abdominal distention were far less common when patients were permitted ambulation within the first 24 hours and prompt resumption of a normal diet. These complications occurred only 9 times among the 571 early and promptly ambulated patients but followed 22 of the 157 operations in the late group.

Genitourinary complications. The total number of individuals who required catheterization once postoperatively because of inhibition of the bladder was proportionately higher in the prompt than in the late group. However, the necessity for repeated catheterizations was far less frequent after patients were up and about on their feet.

The incidence of total complications of significance was progressively reduced by progressively rapid postoperative mobilization. This incidence fell from 67 per cent among the patients in the late group through 59 per cent in the delayed group, 45 per cent in the early group, and 39 per cent in the prompt group. The favorable influence of early and prompt ambulation on the incidence of such significant postoperative complications is apparent.

Recurrence after Hernioplasty

In studying recurrence after hernioplasty it is important to allow a follow-up interval of at least 1 to 5 years. Consequently, all the hernias repaired at the hospital subsequent to 1953 have not been included in this survey. Because of the absence of recurrences during infancy and childhood, this group has also been omitted.

Fifteen hernias in the late group and 1 in the prompt were immediately eliminated from further study by death of the patients in the hospital. Also discarded because of death after discharge without examination at least 1 year later or our failure to trace patients for the same length of time, were 22 hernias in the late group, 8 in the delayed, 17 in the early, and 35 in the prompt group. The remaining 736 repaired hernias were adequately followed, reexamined, and available for evaluation of the influence of rapidity of postoperative ambulation on the rate of recurrence. In the late group there were

TABLE 6

SURGICAL CONVALESCENCE

Correlation of postoperative activity with rate of recurrence following hernioplasty*

Analysis 1933–1953, inclusive	Hernias repaired				
	Adults				
	Postoperative ambulation				
	Late	Delayed	Early	Prompt	Total
Number of hernias repaired	168	23	247	396	834
Eliminated from further study by P. O. death of patient	15	0	0	1	16
Lost by death after discharge without F. U. examination	6	1	2	10	19
Discarded because of failure to trace for at least 1 yr.	16	7	15	25	63
Number adequately followed for 1–20 years	131	15	230	360	736
Known recurrences	13	0	12	23	48
Rate of recurrence (per cent)	10.0	—	5.2	6.4	6.5

* Correlation of postoperative activity with rate of recurrence following hernioplasty.

13 recurrences, an incidence of 10 per cent. In the delayed group there were no recurrences, but the number is too small to be of clinical significance. In the early group, that is, among those patients who were ambulatory on the first postoperative day, there were 12 recurrences, an incidence of 5.2 per cent. Twenty-three recurrences developed among the 360 repaired hernias in the prompt group, an incidence of 6.4 per cent. These represent absolute known rates of recurrence among those patients who were examined 1 to 20 years after operation (TABLE 6).

A correlation of postoperative activity with the number of hernias repaired, the number adequately followed, and the known recurrences is expressed graphically in FIGURE 1. The actual number of such recurrences has increased with the increase in the number of hernioplasties performed annually at the hospital during the years 1933 to 1953. However, in spite of the progressive decrease in the average length of time spent in bed by each patient and the equally impressive decrease in the duration of total convalescence, the rate of known recurrences has fallen from 16.3 per cent during the years 1933 to 1937 to 6.4 during the last 5 years of this period. These data suggest that confinement to bed after hernioplasty may be negligible and that the total period of recovery may be reduced to about one third of the time formerly thought to be essential for convalescence without increasing the rate of recurrence.

Duration of Convalescence

Convalescence begins when the operation is completed and terminates when the patient returns to the work which was interrupted when he entered the hospital for surgical treatment.

Many patients at the Bassett Hospital are farmers or members of farm fami-

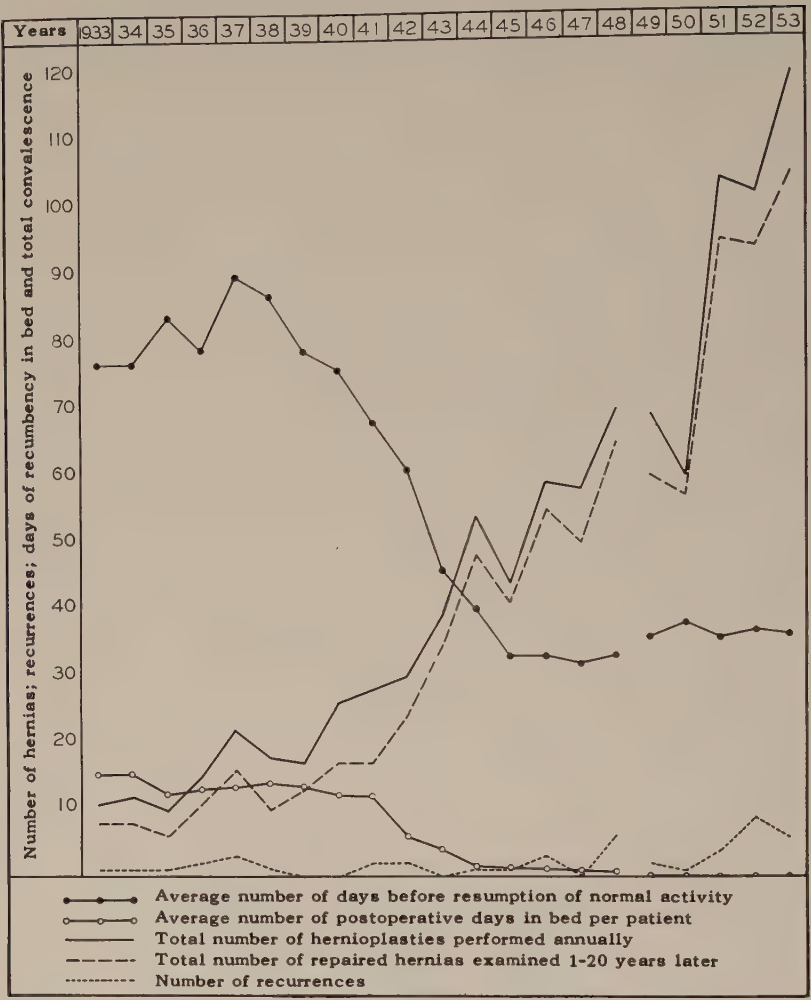

FIGURE 1. Graphic correlation of postoperative activity, days in bed, and total convalescence with the number of hernias repaired, the number adequately followed, and the known recurrences.

lies. Frequently no help is available to supplant the farm operator during periods of illness or postoperative convalescence. For this reason it is essential that illness or convalescence be brief and that return to full agricultural activity be as prompt as possible. Numerous inhabitants within the village are employed as clerks, supervisors, inspectors, and laborers in one of several large industrial plants within a radius of 50 miles; when these patients are injured they are covered by compensation or disability insurance. In Cooperstown and its environs there are also many elderly people who have retired. Consequently, several widely divergent groups of individuals are available for a

TABLE 7

SURGICAL CONVALESCENCE

Comparative data on duration of convalescence, postoperative complications, and number of recurrent hernias among different groups of patients, 1949-1953, inclusive*

Classes of patients	Collected data					
	Number of operations	Weeks of convalescence before return to full activity	Postoperative complications		Number of hernias repaired	Known recurrences
			Number	Incidence		
Students	11	2.8	2	18%	11	0
Clerks, supervisors, inspectors, etc.	40	3.0	20	50%	45	0
Farmers	48	4.0	22	46%	54	1
Workers with disability insurance—no delay	14	4.0	5	36%	16	1
Laborers with compensation insurance—no delay	27	4.1	14	52%	30	1
Other laborers and mechanics	40	4.7	24	60%	45	4
Retired and unemployed workers	56	5.5	51	91%	58	4
Housewives	46	5.9	25	54%	53	5
Laborers with compensation insurance—full delay	34	7.0	10	29%	39	2
Workers with disability insurance—full delay	38	7.8	33	87%	45	5
Children	52		14	27%	59	0
Total	406				455	23

* Tabulation of data on duration of convalescence, postoperative complications, and number of recurrent hernias among different groups of patients, 1949 through 1953.

comparative study of surgical convalescence in relation to early postoperative ambulation.

TABLE 7 presents a chronologically correlated summary for each group, of the weeks of convalescence before return to full activity, the number and incidence of postoperative complications, the number of hernias repaired, and the known recurrences among the patients operated on during the years 1949 to 1953.

Students, clerks, supervisors, and other nonmanual workers returned to their normal activities in 3 weeks; there were no known recurrences among 56 hernias repaired in these groups. Farmers, whose labor involves long hours of strenuous activity, returned to full duty in 4 weeks; their incidence of postoperative complications was high, but only 1 recurrence was known among 54 hernias repaired. Some workers with disability and compensation insurance promptly resumed their normal activities, often arduous manual labor, in 4 weeks, without regard to the periods of disability with pay allowed by their insurance policies. In these 2 groups there were 2 known recurrent hernias among 46 operations. Others in the same 2 categories took full advantage of the authorized periods of disability and did not resume their normal activities until 7 to 8 weeks after operation; among these there were 7 known recurrent hernias among 84 repaired. Laborers and mechanics without such financial protection returned to work after an average convalescence of slightly less than 5 weeks; 4 hernias recurred among 45 operations. The incidence of postoperative complications was highest among the retired and unemployed patients; many were elderly and often came for operation only because of pain due to the onset of complicating incarceration, strangulation, or obstruction. The incidence of recurrences was also increased among this group despite freedom from strenuous exertion during and after convalescence. Because of their varied activities and gradual resumption of household duties, the duration of the convalescent period was hardest to determine with accuracy among housewives. The higher number of recurrences in this group was due at least partially to the proportion of postoperative ventral hernias among these patients, several of whom had been operated on previously. Recurrent hernias in infancy and childhood are very uncommon.

Conclusion

Many postoperative complications are favorably influenced by early and prompt ambulation after hernioplasty. These include bronchopneumonia, pleurisy, massive pulmonary atelectasis, pulmonary embolism, possibly pulmonary infarction due to small emboli, gastric dilatation, abdominal distention, and inhibition of the bladder requiring repeated catheterizations. Exceptions are local hematomata in the wound, cord, testis, or scrotum, partial pulmonary atelectasis, thrombosis of the deep veins of the legs, and inhibitions of the bladder for which a single catheterization is adequate.

The rate of recurrence following hernioplasties of all types is distinctly lower among patients who are out of bed and walking within 24 hours after operation.

Prompt postoperative ambulation also permits a generally accelerated convalescence and early return to normal activity, be it clerical or comparable employment, the manifold duties of a housewife, heavy farm work, or strenuous mechanical or manual labor.

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CONCLUDING REMARKS

By F. Curtis Dohan and N. Henry Moss
Departments of Medicine and Surgery, and the Harrison Department of Surgical Research, School of Medicine, University of Pennsylvania, Philadelphia, Pa.

The marked change in the physician's attitude toward prolonged postoperative bed rest has been relatively recent. Why has a similar change in attitude toward posthospitalization activities and the duration of total convalescence not occurred?

This monograph has explored the factors influencing the total duration of the convalescent period after surgery. The studies by Gold clearly indicate that a marked decrease in the total convalescent period is possible. Comparison of his data with those of Saffeir and Fleming shows that the average time for return to full duty of Air Force personnel after common surgical procedures is about one third of the average time for civilians of similar age. Furthermore, Johnston and Bartels, working in an industrial community, and Powers in a rural area, have demonstrated that many civilian patients do, in fact, safely undertake strenuous activity far sooner in the postoperative period than most doctors customarily recommend. In addition, the studies of Allam and Martin in essentially unprejudiced subjects, that is, racing dogs and horses, have shown that these animals return to the race track after surgery far sooner than would be expected on the basis of the usual practice of human beings.

It would seem from this empirical evidence that the present prolonged convalescent period is not necessary for the majority of patients after common uncomplicated surgical procedures. Rusk has long been an advocate of a more dynamic approach and a more active convalescent period that, undoubtedly, would result in physiological, psychological, and economic benefits to the patient. The effects of negative nitrogen balance on stamina reported by Taylor and Keys; the requirements for wound healing discussed by Dunphy; and the postoperative metabolic and endocrine changes presented by Moore and by Hardy seem insufficient to account for the prolonged convalescent period now customary after common uncomplicated surgical procedures.

The factors influencing a patient's emotional reactions to both the operation and the postoperative adjustment are manifold; frequently these reactions are based on misconceptions and misinformation, as pointed out by Sutherland. The duty of the physician to provide patients with accurate information concerning the conduct of the postoperative period is clear, as is his obligation to pay more attention to the psychological factors.

An examination of the pertinent data presented by both Saffeir and Fleming suggests to us that receipt of insurance benefits or salary or both is not a major factor in the prolongation of convalescence. In fact, a prolonged convalescent period, despite the benefits from sick-leave programs of industry, actually represents a period of significant economic loss to the average worker. One study indicates that the average net wage loss was 45 per cent of the wage that would have been received. In the aggregate there is a tremendous loss to the economy. Hawley has estimated that, if the average postsurgical convalescent period were decreased by one fourth, which seems conservative in view of other evidence presented, the savings to the national economy of the United States would be more than one billion dollars per year. In addition, as pointed out by Berry, the average duration of convalescence has important bearings on national manpower requirements.

Our studies indicate that, although the opinion of the attending doctor is the major factor in determining the total duration of the postsurgical convalescent period, the opinions and practices of individual doctors regarding this matter differ widely. Therefore, as Ravdin emphasized, we must critically re-evaluate our concepts of the conduct and duration of convalescence.

This monograph summarizes the physiological, psychological, and economic factors influencing the postoperative period. It provides physicians with the opportunity to re-evaluate their concepts concerning surgical convalescence.

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